Dynamic Time Metered Delivery (DTMD): Potential Effect on the Goals of the Federal Communications Commission's "National Broadband Plan."

By

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Bachelor of Science
United States Naval Academy, 1983

Master of Business Administration
The Wharton School, University of Pennsylvania, 1992

Submitted to the Engineering Systems Division-System Design and Management Program in Partial Fulfillment of the Requirements for the Degree of

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Abstract

The Federal Communications Commission (FCC) has stated that broadband is the great infrastructure challenge of the early 21st century. On March 16, 2010 the FCC published "Connecting America: The National Broadband Plan". One of the goals of the FCC Plan is having 100M U.S. households with affordable access to actual download speeds of at least 100Mbps and actual upload speeds of at least 50Mbps. The FCC also has the goal that every American should have affordable access to robust broadband (5Mbps) service. This paper examines the potential use of Dynamic Time Metered Delivery (DTMD) in the furtherance of these goals using data and analysis from public sources and TelePulse Technologies Corporation (inventors of DTMD). The key questions the research proposes to answer are:

- Using Hypercube analysis, how would key elements of the value chain for phone companies categorize and react to DTMD as an innovation?
- Are there specific goals of the FCC National Broadband Plan that might be directly furthered by the use of DTMD?

By decreasing the price of broadband performance, DTMD can further FCC goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities. With DTMD and without capital expenditure, the current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current phone lines. The cost for a phone company to provide the service goes from being a capital expenditure to a consumable expenditure. In the case of broadband deployment, for rural communities, less dense urban communities and low income urban communities, private sector business goals and public sector goals conflict. Various parts of a broadband provider's value chain may see needed innovation as potentially disruptive, lacking a robust total market, or lacking a high degree of interest by the service provider (the perceived driver of market volume). While private sector investment in broadband has increased, that funding is focused on more at improving current investment with incremental improvement to market proven technologies. FCC driven investment opportunities and incentives to innovate for the unserved should include opportunities to innovate with technologies that are not fully market proven.

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Biographical Information

BRIAN W. J. POSEY

ACADEMIC BACKGROUND:

Bachelor of Science-
United States Naval Academy, 1983

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PROFESSIONAL EXPERIENCE:

TELEPULSE TECHNOLOGIES CORPORATION
Co-Founder, CEO and President Alexandria, VA and Chester Springs, PA (2001 - Present)
Broadband communications company specializing in "last mile" solutions that devised patented and different way of sending high data rate (HDTV) digital information over phone lines to solve inherent limitations of all forms of the current DSL. This can increase Telco wireline revenue dramatically (~300%), based on using existing phone lines, enabling increased end-customer base and decreases capital costs of installing fiber to users. Also benefits telcos in efficiency and ease of conversion from existing equipment modules. This technique is compatible with existing regulations and overarching industry standards.

VISION COMMUNICATIONS CORPORATION
Senior Vice President Marketing & Strategic Planning Philadelphia, PA USA (1998-1999)
The company was a new telecommunications equipment company. It has proprietary technology for increasing bandwidth on plain copper wire. My mandate was to set up global channels of Value Added Resellers and joint venture partners both in the US and abroad

POSEY CONSULTING INTERNATIONAL
Founder Alexandria, VA (1995-2001)
As a management consultant advised on multiple projects including: telecommunications, privatizations, non-bank financial institutions, housing, and real estate development.

MARS & CO
Senior Strategy Consultant Rio de Janeiro, Brazil and Greenwich, CT USA (1994 -1995)
While based in Rio de Janeiro, Brazil and Greenwich, CT USA contributed to projects that included refranchising analysis for Pepsi Brazil, competitive analysis for Pepsico Food Services, customer profitability study for American National Can, and strategic focus for Xerox Engineering Systems.

DATABANK FINANCIAL SERVICES GROUP
Consultant, Accra, Ghana, West Africa (1992-1994)
West Africa based Investment banking, consulting and financial services group working with local and international investors. Projects included: Privatization Consulting, Analysis of Capital Markets; Identification of projects for foreign investors.

UNITED STATES NAVY
Surface Warfare Officer, Engineering Management/Strategic Planning Australia, Philippines, South Korea, Japan, USA (1983-1990)
Completed various assignments in Asia, Middle East, Europe and the US. Awarded the Navy Achievement Medal and Navy Commendation Medal; Also awarded the Engineering and Gunnery Excellence Efficiency Awards

OTHER INFORMATION: Traveled and conducted business in over 40 different countries; Fluent in French, partial working ability in Portuguese; Awarded the Secretary of the Navy's Navy Achievement Medal and Navy Commendation Medal for outstanding leadership and management;

Acknowledgements

To my dearest Joana,

I want to thank you for your support and love. Completing this program is one of the significant twists and curves on a road less traveled…the one Robert Frost tells us makes all the difference. As with most goals of great consequence, the path is not straightforward and there are no vetted mapping programs that either give you the next move or declare that you have arrived. A journey of 1,000 miles begins with a single step. Your love, support, companionship and sage counsel helps to ensure that this life we share is not a journey of ME but a journey of WE … and WE can make the steps together. Without your partnership, the journey is cold and lonely and of questionable value.

To my children, Ekow and Efua,

Please watch what your mother and I accomplish and attempt to accomplish, in our time on the planet. Be wary of others' bullet point assessments of what constitutes success and failure. 99% of the bullet point information is both interesting and useless. Gather wisdom from the struggle to succeed and the true pain and pleasure from real failure and success. Seek to achieve goals that will benefit more than just you. In the future, should you dare to read this document, please do not let the learning stop at "Daddy went to MIT and got a masters degree." Instead, ask me why I sought the knowledge and how I later applied the knowledge. Finally, perhaps because my goals in life are very entrepreneurial; I want you to think of crafting your life paths with a bit of help from Teddy Roosevelt.

> "It is not the critic who counts: not the man who points out how the strong man stumbles or where the doer of deeds could have done better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood, who strives valiantly, who errs and comes up short again and again, because there is no effort without error or shortcoming, but who knows the great enthusiasms, the great devotions, who spends himself for a worthy cause; who, at the best, knows, in the end, the triumph of high achievement, and who, at the worst, if he fails, at least he fails while daring greatly, so that his place shall never be with those cold and timid souls who knew neither victory nor defeat."

Theodore Roosevelt
"Citizenship in a Republic," Speech at the Sorbonne, Paris, April 23, 1910

Executive Summary

In early 2009, Congress directed the Federal Communications Commission (FCC) to develop a National Broadband Plan to ensure every American has "access to broadband capability." On March 16, 2010 the FCC published "Connecting America: The National Broadband Plan". (FCC Broadband Plan, 2010)

The FCC Plan has goals of having 100M U.S. households with affordable access to actual download speeds of at least 100Mbps and actual upload speeds of at least 50Mbps. The FCC also has the goal that every American should have affordable access to robust broadband (5Mbps) service. This paper examines the potential use of a new telecommunications technology called "Dynamic Time Metered Delivery (DTMD)" in the furtherance of these goals using data and analysis from public sources and from TelePulse Technologies Corporation (inventors of DTMD). The key questions the research proposes to answer are:

- Using Hypercube analysis, how would key elements of the value chain for phone companies categorize and react to DTMD as an innovation?
- Are there specific goals of the FCC National Broadband Plan that might be directly furthered by the use of DTMD?

First, the paper will explain why broadband is important and why we need to be worried about our ability to provide ever faster broadband speeds to the masses. Next, the paper will explain what the technology is and what it does and why and how it was invented. Then the paper will examine the technology by its impact in the value chain. With those sections a primer, the paper will show the potential impact the technology on specific goals in the National Broadband Plan.

After having shown the potential impact on the Federal Communications Commission (FCC's) goals, the paper will discuss why FCC goals and private sector goals, in this specific case, may be in conflict and how that conflict might be resolved. Finally, the paper will give some justification as to why the creation of potentially disruptive innovation and telecom infrastructure strategy need to be brought together.

The Importance of Broadband

According to the Federal Communications Commission (FCC), broadband technology is a key driver of economic growth. Because it has the ability to share large amounts of information at ever-greater speeds increases productivity, it facilitates commerce, and drives innovation. Broadband is changing how we communicate with each other, how and where we work, how we educate our children, and how we entertain ourselves. Broadband is particularly critical in rural areas, where advanced communications can shrink the distances that isolate remote communities. (FCC: Website http://www.fcc.gov/broadband/)

What is Dynamic Time Metered Delivery (DTMD)?

Dynamic Time Metered Delivery (DTMD) is a unique physical layer communication method. DTMD uses enhanced time-based techniques to enable and control the flow of more data/Hertz through a variety of transmission media including existing and new copper phone lines, coaxial cable, fiber optic, powerline and wireless RF, Optical and Acoustic, to and from a comprehensive, multi-function customer data gateway. For a given distance that data has to travel, DTMD allows either more data to travel the same distance or the same amount of data to travel a much longer distance, and variations in between. (DeFrancesco, et al ,2007) DTMD is a signal processing technology that is first being applied to copper based networks due to the current need for price performance enhancement over what is available with the various forms of Digital Subscriber Line (xDSL) technology.

DTMD Potential Impact on the Phone Company Value Chain

In this section we will analyze potential disruption in the value chain where Dynamic Time Metered Delivery (DTMD) deployment would occur. First, the value chain will be described. Then an overview of DTMD development will be given in order to give relevance to the potential entry in the telephony marketplace. The hypercube of innovation as described by Allan Afuah and Nik Bahram will then be used to analyze the technology within the value chain of the phone company. In doing this analysis, the paper shows that even in the face of demonstrated price/performance advantage why might certain elements of the value chain not pursue (or even block) DTMD based innovation?

DTMD Potential Impact on the FCC's National Broadband Plan

The National Broadband Plan has a variety of recommendations and goals to enhance broadband availability and usage in the United States. The plan recommends that the country adopt and track six specific goals to serve as a compass over the next decade. Use of DTMD potentially has a direct impact on two of these most ambitious goals (FCC Broadband Plan, 2010):

> Goal No. 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.

> Goal No. 3: Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

By decreasing the price of broadband performance, DTMD can further FCC goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities.

Bringing Potentially Disruptive Innovation and Telecom Infrastructure Together

In the case of broadband deployment, for rural communities, less dense suburban communities and low income urban communities, private sector business goals and public sector goals may conflict because the Federal Communications Commission (FCC) has public sector goals of ubiquitous broadband and the private sector has financial goals of return on investment and low risk. (FCC Broadband Plan, 2010)

While private sector investment in broadband has increased, that funding is focused on more at improving current investment with incremental improvement to market proven technologies. (FCC Broadband Plan, 2010) FCC driven investment opportunities and incentives to innovate for the unserved should include opportunities to innovate with technologies that are not fully market proven but can potentially address both private and public sector goals. Otherwise the private sector incentive will be to continue squeezing returns from their large current infrastructure investment and avoiding unprofitable customers on the fringe. A technology like DTMD, can help in bringing the private and public goals together because it can potentially make the broadband ubiquity goals of the FCC financially achievable (or even attractive) for the private sector. (Chilson, 2002) (FCC Broadband Plan, 2010) (DeFrancesco, 2003)

Conclusion

By decreasing the price of broadband performance, Dynamic Time Metered Delivery (DTMD) can further Federal Communications Ccommission goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities. With DTMD and without capital expenditure, the current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current phone lines. The cost for a phone company to provide the service goes from being a capital expenditure to a consumable expenditure. Use of Hypercube Analysis shows that various parts of a broadband provider's value chain may see needed innovations (such as DTMD) as potentially disruptive, lacking a robust total market, or lacking a high degree of interest by the service provider (the perceived driver of market volume). In the case of broadband deployment, for rural communities, less dense urban communities and low income urban communities, private sector business goals and public sector goals conflict. Private sector business goals and public sector goals conflict because the FCC has a public sector goal of ubiquitous broadband and the private sector has financial goals of return on investment and low risk. While private sector investment in broadband has increased, that funding is focused on more at improving current investment with incremental improvement to market proven technologies. FCC driven investment opportunities and incentives to innovate for the unserved should include opportunities to innovate with technologies that are not fully market proven.

Specific Areas for Further Research

It is important to note that Dynamic Time Metered Delivery (DTMD) is not a copper technology; it is a signal processing technology being applied to a copper infrastructure. This paper has examined DTMD as an application used on copper wire. Further research and analysis should concentrate on using the processing gain of DTMD in Broadband over Powerline, remote utility monitoring, and low cost upgrade for copper based middle mile infrastructure. With fiber networks, DTMD can offer processing gain, but research would have to determine the nature and significance of that potential gain. Doing these types of analysis would give policy planners a much fuller range of infrastructure expansion options. Since the economics of expanding fiber networks is driven by population density and DTMD can be either a non-capital expenditure system upgrade or a fiber enabled upgrade; there is uncertainty and risk in expansion related to projections of population growth. This also presents research opportunities. If DTMD based equipment becomes commercially available, then the endpoint of the research opportunities could be twofold:

1. The design of telecommunications infrastructure upgrades using "Real Options" that include the use DTMD.
2. Use of Lessard's RAT's (Relevant, Appropriable and Transferable) test to examine the global growth possibilities and target market for the technology.

The Importance of Broadband

In early 2009, Congress directed the Federal Communications Commission (FCC) to develop a National Broadband Plan to ensure every American has "access to broadband capability." On March 16, 2010 the FCC published "Connecting America: The National Broadband Plan". (FCC Broadband Plan, 2010)

The FCC Plan has goals of having 100M U.S. households with affordable access to actual download speeds of at least 100Mbps and actual upload speeds of at least 50Mbps. The FCC also has the goal that every American should have affordable access to robust broadband (5Mbps) service.

According to the Federal Communications Commission (FCC), broadband technology is a key driver of economic growth. The ability to share large amounts of information at ever-greater speeds increases productivity, facilitates commerce, and drives innovation. Broadband is changing how we communicate with each other, how and where we work, how we educate our children, and how we entertain ourselves. Broadband is particularly critical in rural areas, where advanced communications can shrink the distances that isolate remote communities. (FCC: Website http://www.fcc.gov/broadband/)

The FCC further states that the term "broadband" refers to advanced communications systems capable of providing high-speed transmission of services such as data, voice, and video over the Internet and other networks. Transmission is provided by a wide range of technologies, including digital subscriber line and fiber optic cable, coaxial cable, wireless technology, and satellite. Broadband platforms make possible the convergence of voice, video, and data services onto a single network. (FCC: Website http://www.fcc.gov/broadband/)

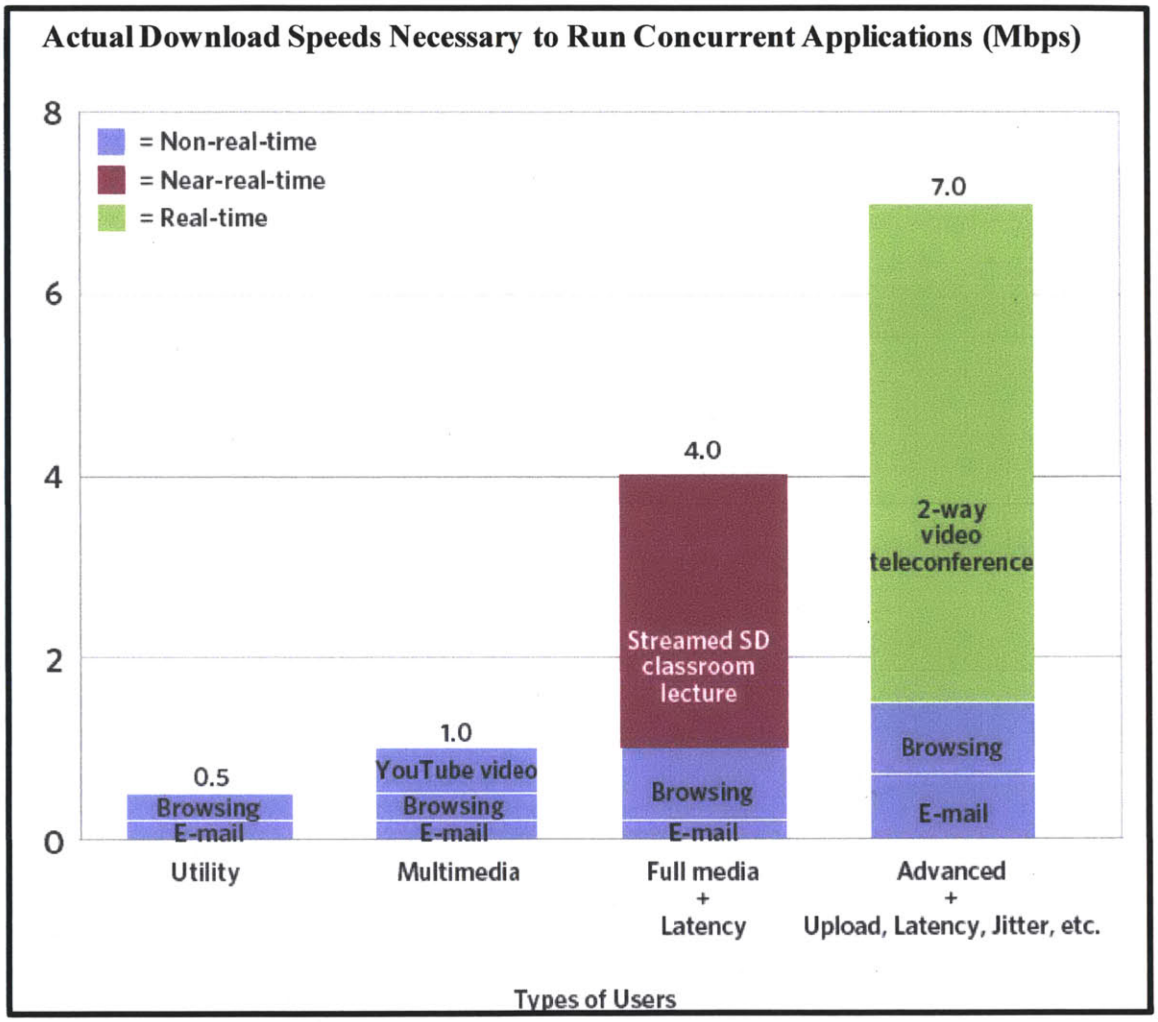
Simply put, broadband is a faster way for you to gain access to the Internet and the sites or pages of interest. Think of a dialup connection like a garden hose. Only a certain amount of water can pass through it. Broadband is then more like a fire-hose that can bring in the same thing, only much faster.

Every time someone goes to a web page, there are files that must be sent to their computer such as the page itself, images, and other components that make up each page of interest. These files vary in size and generally, the more files that must be transported; the longer it takes for the page to load. A broadband line can send those files to your computer faster than a dial-up line can and therefore, the user can see the entire page faster.

Do you need broadband?

The answer is generally no, you probably don't NEED it. If you work online and time is money, then perhaps you need it. A more appropriate question would be whether you want it or not. If you spend a great deal of time at your computer, have the desire to download large programs, or often get frustrated with slow loading pages, you may want to consider increasing your speed by 50-100 times with broadband. Figure 1 shows what actual speeds are necessary for certain applications.

When you might actually have a need for it is if you want to do some things that are otherwise virtually impossible, like watch live broadcasts, watch videos, or play Internet games. As can be seen in Figure 1, if you are just quickly browsing or only want email, 500kbps is sufficient. If you are also adding 2-way video teleconferencing and you would like to have a smooth and natural seeming conversation, then you will need to move up to 7Mbps. If there are multiple users in the same location doing similar data intensive activities, then more will be needed. (FCC Broadband Plan, 2010)



Federal Communications Commission, National Broadbnad Plan 2010

Figure 1: Actual Download Speeds Necessary to Run Concurrent Applications (Mbps)

There are comparisons from history on acceptance of new innovations. Having broadband can best be compared to automobile ownership or access to electricity. Most people did not have automobiles originally or access to electricity but over time they became affordable and part of everyday life.

This can be a struggle in both government and business. The problem that both government and business are trying to resolve is how to work out the movement of high quality broadband access from a consumer choice to something that's accessible to everybody. We should expect that over time that will happen in society. There will be tiered structures where offered services which will cost more and that some people will pay for, but under pinning it everybody will have an equitable access to the same quality of service even if they choose to opt out.

High speed broadband and peoples' daily lives

Today, we live in the Internet Age. The Internet is rapidly transforming society and the global economy, becoming as essential for daily living and commerce as any other infrastructure. It is believed that America will benefit greatly from expanding the ubiquity, capacity, and adoption and use of broadband connections to the Internet. The US Broadband Coalition in their "Report of the US Broadband Coalition on a National Broadband Strategy" September 24, 2009 has highlighted the following areas (US Broadband Coalition, 2009):

- **Economic Development and Job Creation**. Putting innovation and investment in broadband connections will stimulate the economy, create jobs, increase worker productivity,
- **Health Care and Emergency Medical Response.** Broadband connectivity can enable cost-effective health management systems and contribute to the effective management of all aspects of healthcare delivery

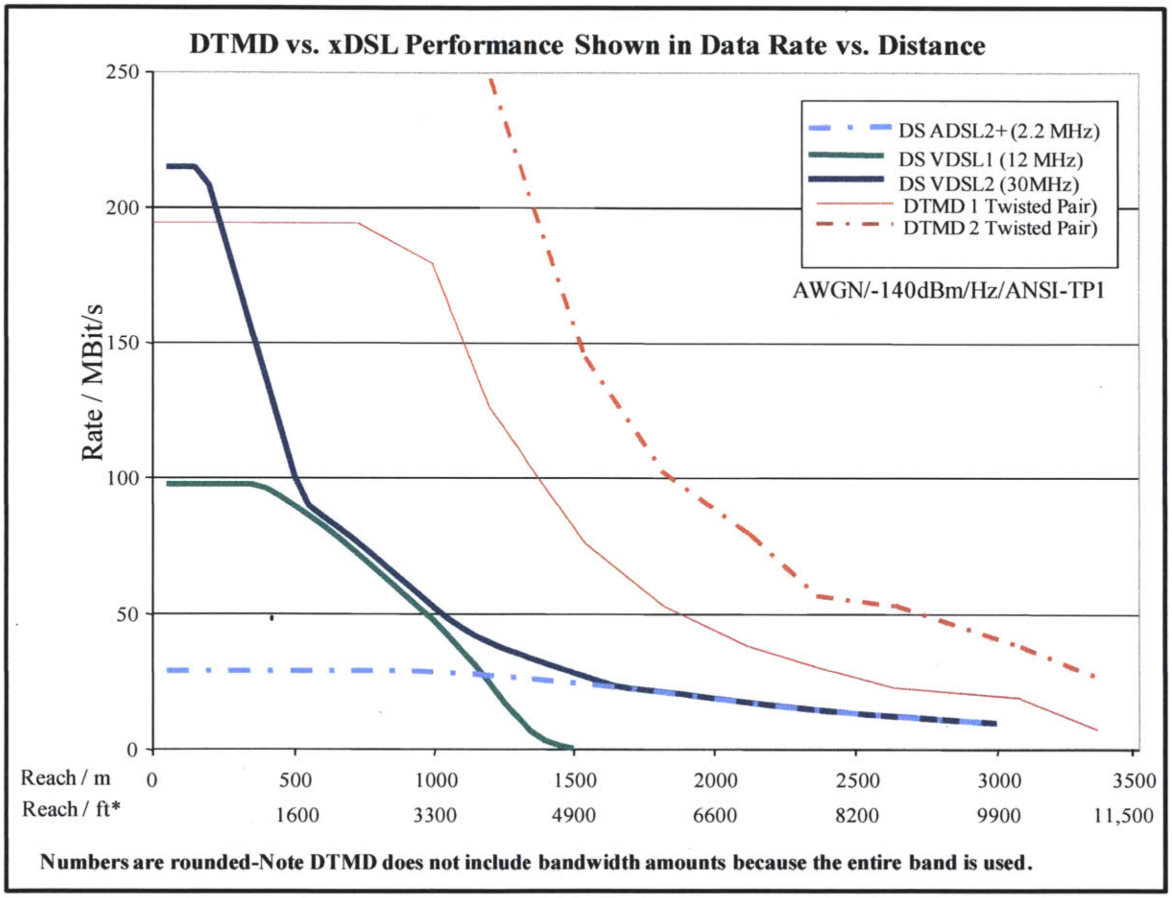
- **Education.** Ubiquitous, affordable broadband connectivity to the Internet will ensure that all students (K-12 and beyond) have access to high-quality teaching and educational resources.
- **Energy and Environmental Sustainability**. Modern high-performance broadband infrastructure offers tremendous opportunities to conserve energy, enhance efficiency, and protect the environment. Smart grids, smart buildings, and automated traffic management controls can slash energy costs, and increase reliability. Effective use of broadband is key to making this happen.
- **Public Safety and Homeland Security**. Interoperable high-speed networking can transform public safety, homeland security, and emergency response by enabling rapid and coordinated communications and service delivery.
- **People with Disabilities**. High-speed broadband connectivity to the Internet offers tremendous potential benefits for people with disabilities by helping to level the playing field for individuals who cannot see, hear, or get around. When these individuals can access the Internet through broadband connectivity, they can take advantage of more job opportunities, education, social engagement, commerce and recreation.

Broadband access, at ever increasing speeds, gives users the capacity to do things that they already try to do online and often are not able to do very well because of the speed. The better the broadband access the more users will be able to do those things as a routine. As with automobiles and electricity, average people will be able to build broadband into their lives.

What is Dynamic Time Metered Delivery (DTMD)?

Dynamic Time Metered Delivery (DTMD) (United States Patent # 7,236,451) is a unique physical layer communication method. DTMD uses enhanced time-based techniques to enable and control the flow of more data/Hertz through a variety of transmission media including existing and new copper phone lines, coaxial cable, fiber optic, powerline and wireless RF, Optical and Acoustic, to and from a comprehensive, multi-function customer data gateway. For a given distance that data has to travel, DTMD allows either more data to travel the same distance or the same amount of data to travel a much longer distance, and variations in between. (DeFrancesco, et al 2007)

Various forms of Digital Subscriber Line (xDSL or DSL) segregate the frequencies within signal bandwidth for the various forms of DSL technology. No individual form of DSL uses the entire bandwidth. Since DTMD uniquely uses all frequencies in the signal bandwidth in conjunction with time and code domain encoding, the technology achieves a processing gain of 10dB more than xDSL. This benefit can be used several ways: One in data rate by extending the upper limit, another is reach, the distance the same amount of data can travel, and the third is rejection of interferers by that amount. DTMD does not have the intrinsic mechanism that causes coherent (co-channel) interference that all xDSL is subject to since it has no frequency bins. Figure 2 shows the rate vs reach performance of DTMD against the best of xDSL. The technologies are compared using publicly available data on tests with Spirent Loop simulators. Adjacent wires in the bundle carrying the same DSL type will have carriers at the same frequency. So, the sidebands lay on top of each other causing coherent signal loss. Conversely, all interfering signals in DTMD are treated the same as noise energy. As a true full broadband signal, DTMD possesses that 10dB of rejection due to processing gain that a Fourier or carrier-based signal structure cannot achieve. DSL has a further challenge in both ingress from and egress to terrestrial broadcast and Ham (shortwave) radio signals. DTMD does not have this problem because it does not generate jamming raspy sounds. Rather it adds only a very little bit of hiss like sound (Garth et al 1999) (DeFrancesco, 2003).



Infineon Technologies: Future Proof Telecommunications Networks with VDSL2, July, 2005 Stephan Wimoesterer; DeFrancesco, R.E. (2003) —Dynamic Time Metered Delivery, Hyper-Broadband on Phone Lines to replace DSL, A Technical Treatise‖ TelePulseTechnologies Corporation Copyright

Figure 2: DTMD vs. xDSL Performance Shown in Data Rate vs. Distance

The far end crosstalk (FEXT) results from many signals on adjacent pairs in a bundle impinging on a given user-pair that is terminated in a receiver. The result is that the background noise level is increased in that user-pair and lowers detection "clarity". Near end crosstalk (NEXT) results from many transmitters at the CO "talking" into a user-pair in the receive mode (Starr et al, 1999).

FEXT is fully line length and frequency dependent and ultimately also dependent on how long in the bundle the interfering signals are present. For example, the signals could be pulled out in mid-cable to be sent to a user along the way. That user would see all the interference but the one at the end of the run would have a mix of coupled interference and a line that that does not have that signal any longer in it. NEXT is frequency dependent as well (Starr et al, 1999).

Adjacent wires in the bundle carrying the same DSL type will have data carriers at the same frequency. Therefore, the sidebands (like AM radio stations) lay on top of each other causing significant coherent signal loss. Conversely, all types of interfering signals in DTMD are treated the same as noise energy. As a true full broadband signal, DTMD is immune to that special loss that keeps DSL from filling the existing bundle of customer wire pairs at the high data rates (Starr et al, 1999) (DeFrancesco, 2003).

Proof of concept for DTMD was validated in a detailed white paper describing simulations and model performance. Further independent proof of concept analytically has been verified by a venture fund, using evaluators from University of Pennsylvania, Lucent, AT&T, and Stevens Institute of Technology. (Weerackody, 2004) The company made some comparisons with the current xDSL performance using the constraint of 10 ^-7 BER and "6dB" of reduced signal to noise margin. In a scaled model version called the "wind tunnel" they did test within that constraint. (DeFrancesco, 2003) The specific test cases run were:

1. Spirent-simulated 10,600 ft. channel with 2 bridged taps: 1500ft from each end

2. Case 1: 24 adjacent-pair Asymmetric Digital Subscriber Lines (ADSL) and one with our DTMD signal showing an Signal to Disturber Ratio (SDR) of 26dB as measured at the output of a Spirent Line Simulator.
3. Case 2: 6T1 lines in the bundle showing an SDR of 32dB.
4. Injection of 6 dB additional equivalent amount of noise into the Wind Tunnel using several spectral shapes to emulate the disturbers and show that the DTMD performance possesses the margins that the US Telcos seek. The results were as expected, that disturber spectral shape had no effect on DTMD performance.
5. At an equivalent data rate of 20Mbps in both cases, the system achieved a RAW BER of 4.9 x 10 ^ -3 easily correctable to 10 ^ -8 by conventional methods. This points to the system's robustness in the face of commonly used constraints.

How Did We Get DTMD?

The founders of TelePulse saw the need some years ago to democratize the access to knowledge globally. They believed that if actions are not taken to lower the barriers to access global knowledge the "Digital Divide" will widen.

The team gave themselves a goal of finding out how to remove the technical barriers that were in the digital divide. They were looking for the greatest impact to essentially even out the access to all people. An opportunity was found both in the ubiquity of the phone line and struggles of the phone company to fully and efficiently use the various forms of Digital Subscriber Line (DSL). In the team's opinion, performance increases in DSL were becoming more and more expensive and full utilization of the current infrastructure was becoming less and less. Their approach to this was different than the incumbent phone equipment makers. The team believed that those groups essentially took modem technology (frequency based) and used it to send data over the phone lines. All other improvements in the area we call DSL have been incremental to that first stage. Because of that start, the technology is pushing more and more data and generating more and more noise. This also spawns another industry of other venders trying to compensate for the noise. The TelePulse team thought that there was a better way to approach this problem.

The TelePulse team felt that the noise inherent in the system and its effect on the movement of data was an analogous situation to what the military had over 30 years ago. So, the military had a need far greater than the phone company to get a signal through a hostile environment. The military had to be able to communicate, and collect and transmit sensor data even when there was Meaconing, Intrusion, Jamming, and Interference (MIJI) (these are various forms of either friendly interference or hostile jamming). So the team approached the problem the way the military approached the problem of MIJI.

How is DTMD positioned?

TelePulse believes that Dynamic Time Metered Delivery (DTMD) can bridge the gap between xDSL and Fiber and postpone radically or eliminate excessively costly physical plant overhauls. While DTMD's rates by themselves for a single line cannot be much higher than the various forms of digital subscriber line technology (xDSL) due to Shannon limits, the aggregate rates in a bundle allowing for crosstalk are far better for DTMD than xDSL due to its immunity to co-channel (phase-coherent, same carrier tone) interference. The company feels that the phone company can keep implementing additional wire pairs with DTMD as the customer demands more data rate. xDSL cannot do that. The customer need for greater data rate must be served or the infrastructure physical plant will be abandoned. TelePulse believes that this should be the right time to begin to work with technologies that will follow VDSL2 (the fastest xDSL variant). According to the company, the best technology to work with should:

1. Utilize the current copper plant
2. Avoid taking fiber to the home
3. Avoid spending more money to expand the fiber plant
4. Be able to expand easily AS DEMANDED BY THE CUSTOMER
5. Be CHEAP and easy to use and install

DTMD Potential Impact on the Phone Company Value Chain

In this section we will analyze potential disruption in the value chain where Dynamic Time Metered Delivery (DTMD) deployment would occur. First, the value chain will be described. Then an overview of DTMD development will be given in order to give relevance to the potential entry in the telephony marketplace. The hypercube of innovation as described by Allan Afuah and Nik Bahram will then be used to analyze the technology within the value chain of the phone company. In doing this analysis, several other questions will also be answered.

- In the face of demonstrated price/performance advantage why might certain elements of the value chain not pursue (or even block) DTMD based innovation?
- How can the Green-Red zone analysis be used, in conjunction with the Hypercube, to proactively decrease barriers noted in the Hypercube analysis?

What is the Value Chain?

The value chain (also often called the "value added chain") is composed of the competence and assets of suppliers of key components and equipment, customers and their customers, and suppliers of complementary innovations. In the case of DTMD, it is still a signal processing technology, not a product. It is first being applied to copper based networks due to the current need for price performance enhancement over what is available with the various forms of Digital Subscriber Line (xDSL) technology. So, the value chain to be evaluated is for phone companies. While the thesis deals with DTMD's potential effect on the goals of the Federal Communications Commission's (FCC) "National Broadband Plan", the technology is being applied to the needs of the phone company. The phone companies would have to demand and use the technology and disruptions in their value chain (independent of the FCC's goals) could be a major barrier to both the adoption of DTMD and the achievement of FCC goals. The technology would have to be put on a chip, so the innovation would impact chipmakers. The chips would have to be used in networking equipment, so the innovation would impact network equipment manufacturers. The networking equipment has to fulfill the needs of phone companies and other broadband service providers. Those service providers are satisfying the needs of broadband consumers as well as other services providers for whom the broadband enhances their services (Skype, VoIP, Facebook and Netflix use the broadband to fulfill the needs of broadband consumers for other products and services). All of these members of the value chain would see an impact from the use of DTMD.

Overview of DTMD development criteria

TelePulse Technologies believes that in the next 10 years consumers will be demanding data rates in excess of 80-100Mbps in a continuous stream...not in a short burst. In their Opinion market need and demand for content has been steadily increasing. Telcos have been using various xDSL versions to catch up with consumer demand. Unfortunately, these are expensive solutions to implement in low density widely disbursed areas. The result is that rural communities are not receiving these benefits because consumers are either too far from the central office or remote terminal or they are too disbursed to gain the effective economies of scale. The company also noticed that consumers that are close enough to get data rates of 50-100Mbps are not getting it if broadband providers do not believe that the community can deliver the required revenue for a short term payback of the capital investment.

The company believes that innovative technologies have shown promise as possible solutions (vs. a product) for sometime but Telcos want products already tested and ready to go from a named vendor. Telcos and their associated technology vendors need to get involved with new solutions at an earlier stage but telco demands for only incremental improvements and large amounts of non-recurring engineering costs prior to any decision making locks out the innovative start-up. Private finance will not act without a guaranteed customer for any projects inside the central office. For them, the risk is that the technology works but the phone company does not feel like buying right now and the rural and underserved areas do not offer a lucrative enough market. Reliance on the many forms of Digital Subscriber Line technology (xDSL) will not solve the phone company need to provide end users with a100Mbps solution and beyond. xDSL has limitations on the number of subscribers at max data rates in a bundle due to its excessive sensitivity to phase-coherent co-channel interference. Fiber-To-The-Home (FTTH) is an outrageously expensive capital investment and cumbersome to transition. (Bingham, 2000)

The company further believed that the most successful technologies can bridge the gap between the various forms of xDSL and FTTH and postpone radically or eliminate excessively costly physical plant overhauls. The customer need for greater data rate must be served or the infrastructure physical plant will be abandoned. In light of this the following development criteria/goals were used:

1. It should solve problems that current systems have not been able to solve.
2. It should fully utilize the current copper plant. The innovative technology should deliver a minimum of 100Mbps at 4,000ft, 20Mbps at 10,0000ft, 5Mbps at 26,000ft, and 1.5Mbps at 32,000ft on a single twisted pair for ALL wires in the wire bundle.

This should be achievable through service providers using Operation and Maintenance funding (instead of Capital Expenditure, or CAPEX, funding).

3. It should maximize access for customers in underserved and un-served areas.
4. It should avoid taking fiber to the home.
5. It should avoid spending more money to expand the fiber and coax plants. It should not require major costly infrastructure upgrades that take years to recover. It should be implemented without putting demands on local governments for towers. It should be implemented without needing satellite coverage for uplink.
6. It should be able to expand easily as demanded by the customer.
7. It should be able to easily expand to 100Mbps. It should be extensible or expandable for increased user needs in data rate and over time.
8. It should be cheap and easy to use and install. It should be easy to implement for end users. It should be easy to understand by installers and users.
9. It should be a radically different way of communicating or a "better" way? It should be capable of being brought to market with current US company capabilities. It should be capable of being brought to market within 2 years, faster with additional funding.
10. It should exploit existing communications infrastructure.
11. It should coexist with existing broadband signals.
12. It should maximize US based technology developers.
13. It should leverage existing US technology to decrease final deployment time to users to less than 2 years?

14. It should develop a technology base that can be used to sell globally to increase balance of trade in US favor.
15. The implementation cost per customer should not, in any case, exceed $2000/twisted pair.

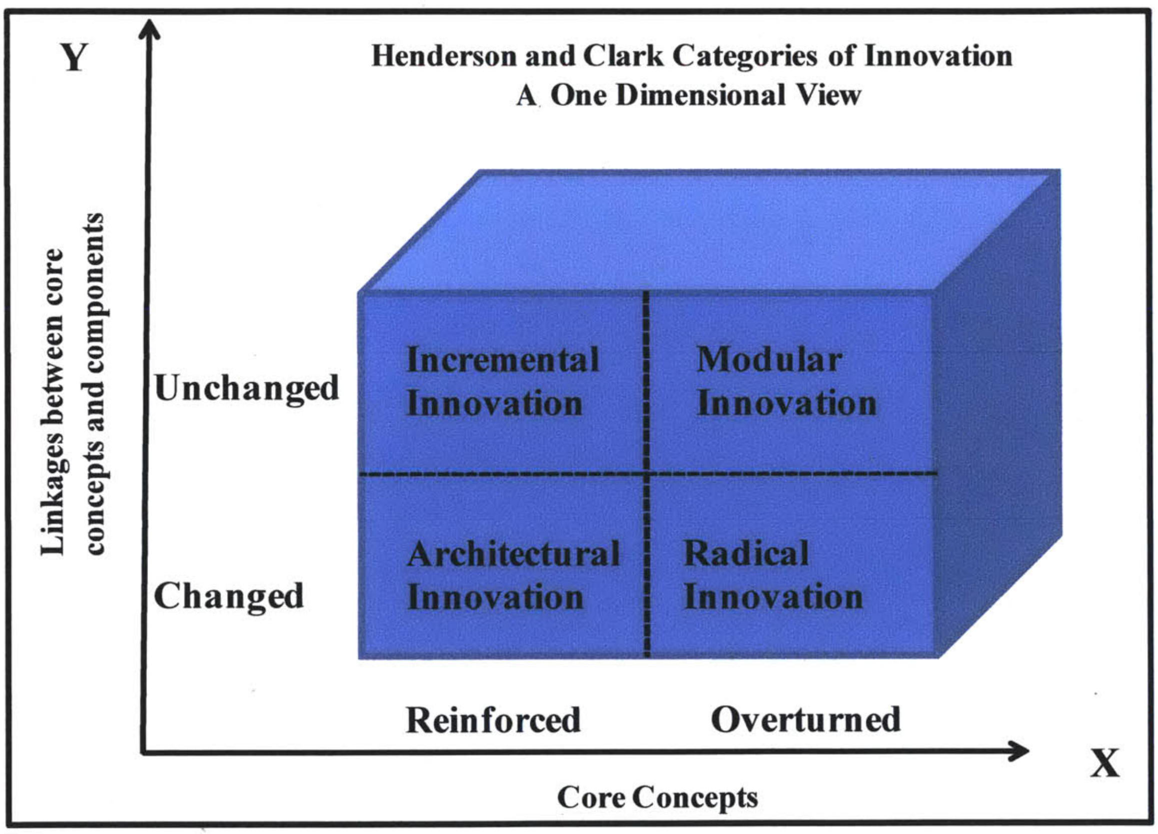
Potential Value Chain Disruption

In this section we will analyze potential disruption in the value chain where Dynamic Time Metered Delivery (DTMD) deployment would occur. The hypercube of innovation as described by Afuah and Bahram will be used to analyze the technology within the value chain of the phone company. Basically, the use of DTMD in the phone company value chain will be evaluated with the hypercube and then the Afuah and Bahram's green red zone map will be used to maneuver through the value chain elements.

According to Afuah and Bahram, scholars of innovation, in an effort to better understand how to manage the process of innovation, have tried to categorize innovations as a function of what the innovations do to the skills, knowledge, investment strategies, and existing products of the innovating entity. (Afuah and Bahram, 1995)

But, as Afuah and Bahram point out, these categorizations of innovations have had one main drawback: by choosing to concentrate on the effects of the innovation on the competence of the innovating entity, they have neglected the effects of the innovations on the competence and assets of suppliers of key components and equipment, customers, and suppliers of complementary innovations. However, an innovation that is, incremental at the innovator/manufacturer level, may turn out to be radical to customers and something else to suppliers of critical complementary innovations; all of which have implications for the success of the innovation. These various faces of one innovation at different stages of the innovation value-added chain are what Afuah and Bahram call the hypercube of innovation. (Afuah and Bahram, 1995)

Henderson and Clark classified innovations according to whether the innovation overturned the existing knowledge of core concepts and components, and the linkages between them. They classified an innovation as either radical, incremental, architectural, or modular, based on the effects which it has on the competence, other products and investment decisions of the innovating entity. Figure 3 graphically demonstrates this concept and shows the relationship of the types of innovation. The principles were first stated by Henderson and Clark in 1990 (Henderson and Clark, 1990).



Henderson and Clark (1990)

Figure 3: Henderson and Clark Categories of Innovation-A One Dimensional View

According to Henderson and Clark, an innovation can be evaluated based on (Henderson and Clark, 1990):

1. How much or if the innovation changes the linkages between core concepts and components
2. How much or if the innovation reinforces or overturns core concepts

Based on the degrees of those changes we can define the types of innovation. From Henderson and Clark, those types of innovation are (Henderson and Clark, 1990):

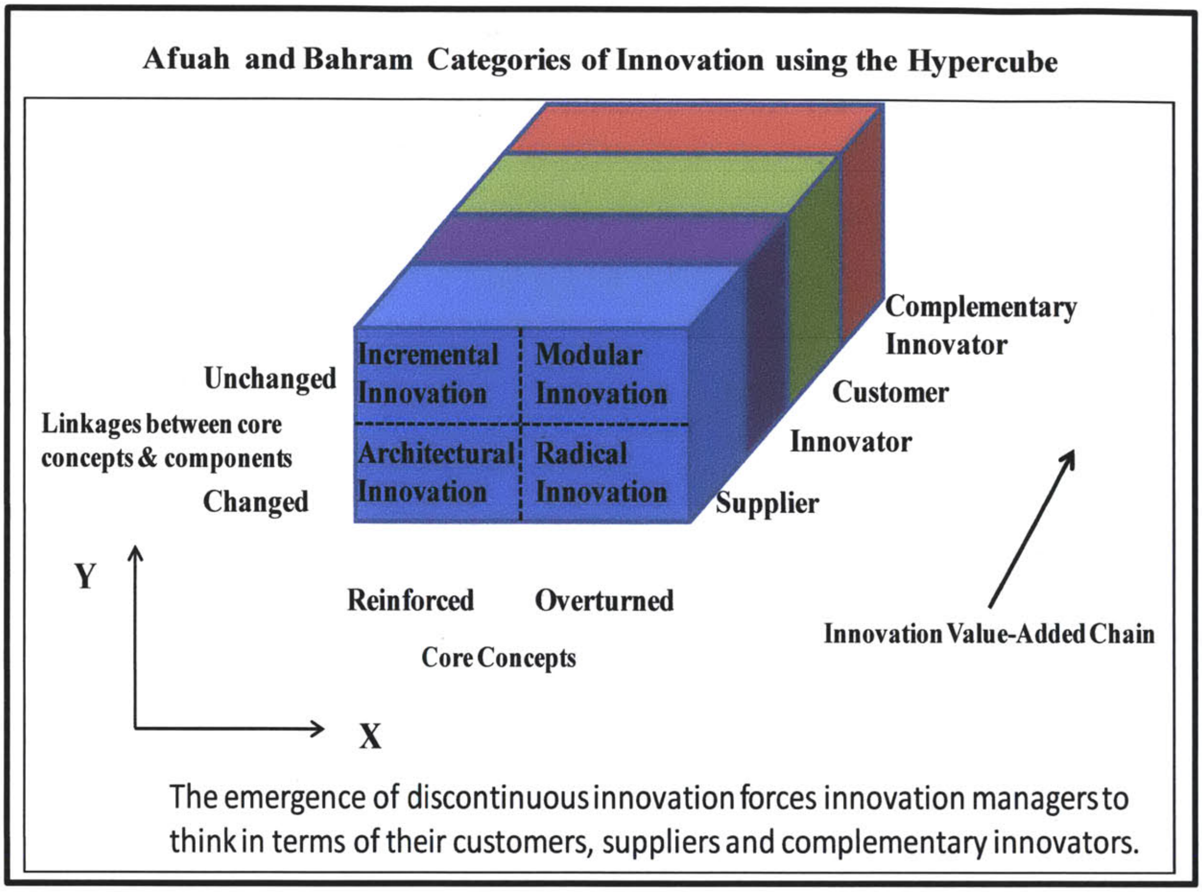
Modular innovation. In a modular innovation, core concepts are overturned, but the architecture remains unchanged. This can be seen in the replacement of analog with digital telephones. To the degree that one can simply replace an analog dialing device with a digital one, it is an innovation that changes a core design concept without changing the product's architecture.

Architectural innovation. In an architectural innovation, core concepts are reinforced, but the architecture is changed. The essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way. This does not mean that the components themselves are untouched by architectural innovation. Architectural innovation is often triggered by a change in a component—perhaps size or some other subsidiary parameter of its design—that creates new interactions and new linkages with other components in the established product.

Incremental innovation. In an incremental innovation, core concepts are reinforced, and the architecture is unchanged. Incremental innovation reinforces the capabilities of established organizations. Improvements occur in individual components.

Radical innovation. In radical innovation core concepts and architecture are both overturned. Radical innovation forces established organizations to ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem-solving approaches. Radical innovation can establish a new dominant design and destroy an old one.

According to Afuah and Bahram, situations may exist where the innovation can be beneficial to the market but harmful to current business and relationships. Based on the severity of the innovation's radicalness it may be best for the innovating company to avoid it. Basically, TelePulse can evaluate value chain impact with the hypercube and use the Afuah and Bahram's green red zone map to maneuver through the value chain elements. Afuah and Bahram's work allows for evaluation of the innovation with the hypercube then, deciding to pursue the innovation using a green-red zone map. This paper suggests evaluation of the innovation with the hypercube then, using a green-red zone map, mitigate the degree of perceived radicalness of the innovation to decrease the amount of resistance to the innovation.



Afuah and Bahram 1995

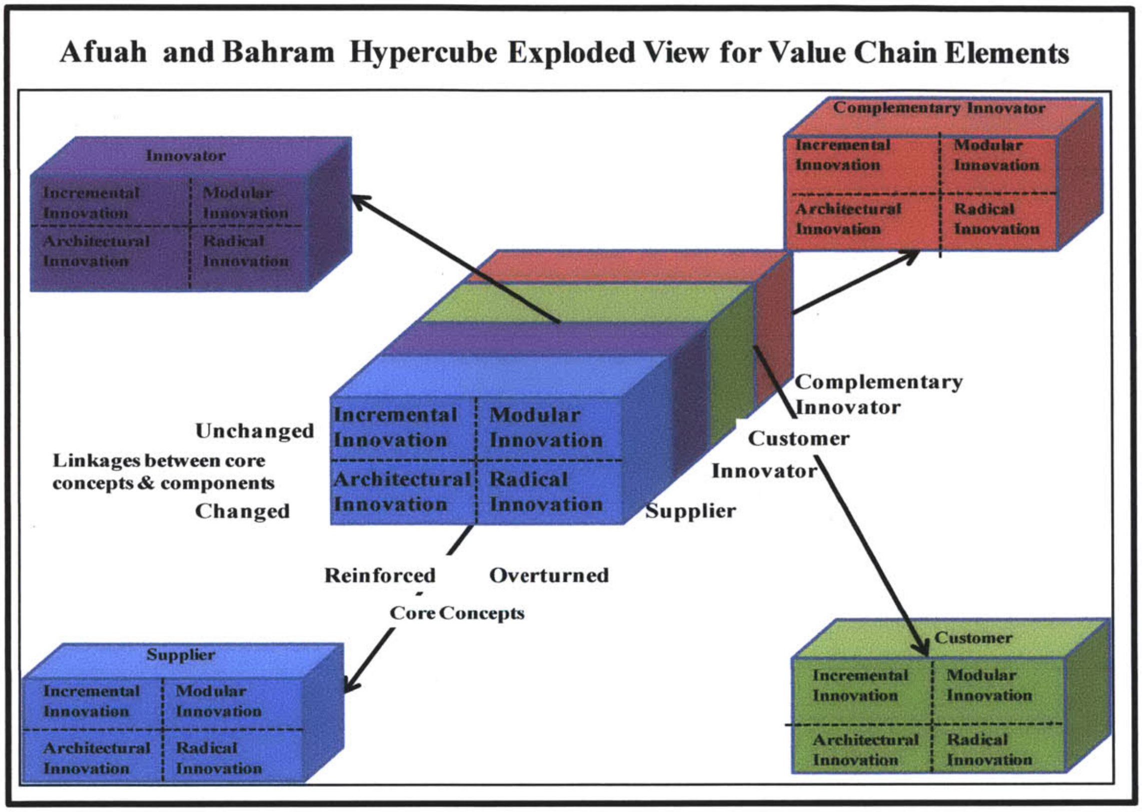
Figure 4: Afuah and Bahram Categories of Innovation Using the Hypercube

The work done by Henderson and Clark is quite useful but there is a problem according to Afuah and Bahram. In a cross functional multidimensional environment with many and varied and often conflicting stakeholders, more sides of the impact of the innovation have to be reviewed. The Hypercube evaluation takes Henderson and Clark many steps further and considers the other members of the value chain. (Afuah and Bahram, 1995) (Henderson and Clark, 1990) This is demonstrated in Figure 4.

In the Hypercube, the X and Y axes are the innovation-classifying factors. The Z-axis is the innovation value-adding chain of supplier of key components, innovator, customer and supplier of complementary innovators. (Afuah and Bahram, 1995)

According to Afuah and Bahram, for many high-technology products, a technology strategy that neglects these various faces of an innovation and dwells only on the effects of the innovation at the innovator/manufacturer level can have disastrous effects. This is especially so for innovations whose success depends on complementary innovations, whose use involves learning and where positive network externalities exist at the customer level. We describe the hypercube of innovation model and use it to examine Dynamic Time Metered Delivery (DTMD) and suggest how DTMD can best be brought to market by maneuvering along the innovation value-added chain using the model. (Afuah and Bahram, 1995)

Figure 5 is an exploded view of the Hypercube to show the various faces that an innovation can assume along the innovation value-added chain. As stated earlier, according to Afuah and Bahram, the common practice of classifying innovations only according to the impact of the innovation on the innovating entity's capabilities vis-à-vis its existing technology and markets is not adequate for high technology products. These products require critical input components and equipment from suppliers, depend on complementary innovations for success, require high levels of learning by customers before use, and often lend themselves to positive network externalities. For such products, the impact of the innovation on the capabilities and assets of suppliers, customers and complementary innovators may be just as critical as that on the innovating entity's competence and assets. The innovator should watch out for the inertia of older complementary innovations and the momentum of newer ones, and take advantage of them. (Afuah and Bahram, 1995)



Afuah and Bahram 1995

Figure 5: Afuah and Bahram Hypercube Exploded View for Value Chain Elements

Dynamic Time Metered Delivery (DTMD) is not a product, it is a technology. It will soon become a suite of products in the realm of signal processing and the first area of use will be on copper twisted pairs. The value chain being evaluated consists of (initially) phone companies' value chain. Since the technology has not yet taken on a product form, the value chain question to be asked is more along the lines of "How should DTMD maneuver through the value chain elements of phone companies to best get into their value chain. A look at the value chain impact of DTMD is useful in determining the potential impact of the technology (pre-product).

Value Chain Impact Elements

First let us examine significant value chain elements and see what impact a technology like DTMD may have. Those elements are: Voice Over Internet Protocol Providers (VoIP); Broadband Consumers; Semiconductor & Circuit Manufacturing; Wired Telecommunications Carriers; and Telecommunication Networking Equipment Manufacturing. Table 1 summarizes the impact.

Perception of DTMD as an Innovation by Various Value Chain Elements

	Linkages Between Core Concepts and Components		**Core Concepts**		**Type of Innovation**
	Changed	Unchanged	Reinforced	Overturned	
VoIP		X	X		Incremental
Broadband Consumers		X		X	Modular
Semiconductor	X			X	Radical
Wired Telecom Providers					
Reg. Wireline		X		X	Modular
FTTN	X		X		Architectural
FTTH	X			X	Radical
Network Equipment	X		X		Architectural

TelePulse Technologies Corporation

Table 1: Perception of DTMD as an Innovation by Various Value Chain Elements

Voice Over Internet Protocol Providers (VoIP)

Define

Industry participants provide voice over internet protocol (VoIP) services to consumers, businesses and government organizations. VoIP technology converts voice signals into digital data packets that are then transmitted using the internet. A number of facilities are used to deliver VoIP services, with the two most popular being the public-switched telephone network (PSTN) and cable infrastructures. VoIP can also be provided by satellite, power lines and wirelessly. (IBIS World Industry Report 51331a, June 2010)

Key External Drivers

The number of broadband connections is crucial. A broadband internet connection is a must for VoIP services. Speedy internet access is provided via cable-, satellite-,fiber- or copper-based networks. As broadband penetration increases, so does the potential VoIP subscriber market. And in the next few years, broadband penetration is set to surge. Faster, higher capacity wireless networks are facilitating the delivery of mobile VoIP. More than 50% broadband connectivity is provided via mobile wireless, so the potential of mobile VoIP is profound. (IBIS World Industry Report 51331a, June 2010)

Competition from wireless telecommunications carriers wired and wireless services are substitutes for VoIP. The competitive position of these alternatives can be strengthened by price cuts and value enhancements. Wired telephony competitiveness is eroding as the falling number of fixed line subscribers undermines wired carriers' ability to cut prices. Conversely, wireless voice is still a strong industry and a major competitor. Wireless voice services will become IP based in the future, which means convergence in the core offerings of these two industries. Aggregate disposable income VoIP services offer a cheap alternative to traditional wired services, but currently offer an inferior service quality. The recent declines in personal disposable incomes, due to the global financial crisis, have increased households' sensitivity to price, boosting the incentive to switch to VoIP. This has facilitated migration to VoIP from other communications devices. The future VoIP industry will become less sensitive to changes in household disposable income as the quality of VoIP is rapidly improving. As the population grows so does demand for communications services. Because VoIP is the cheapest communicative medium, it is gradually satisfying a larger and larger share of demand for "fixed" communications. And as mobile VoIP emerges, the industry will also move on the wireless voice space. (IBIS World Industry Report 51331a, June 2010)

Potential Impact of DTMD-INCREMENTAL

VoIP providers would see the DTMD as an incremental innovation. The core concepts are reinforced, and the architecture is unchanged from their point of view. DTMD would reinforce the capabilities of established VoIP providers. Improvements occur in individual components but the way they move their phone service is no different except that now the basket of potential VoIP users is greatly increased because the number of potential new broadband users is greatly increased.

Broadband Consumers

Define

These are current and potential users of the internet at speeds in excess of 4Mbps. Those who are considered unserved do not have the ability to access speeds greater than 5Mbps. Those who are considered hyper users have the ability to access speeds greater than 25Mbps.

Key External Drivers

1. Affordability of broadband connections.
2. Availability of broadband connections.
3. Knowledge of the importance of being connected and the opportunity to develop the necessary digital skills.
4. Interest in various services and/or applications that require greater and greater amounts of data transfer.

Potential Impact of DTMD-MODULAR

Broadband consumers would see DTMD as a modular innovation. With DTMD the core concept of the best data rate that is available is overturned, but the architecture remains unchanged. To the degree that one can simply replace a current xDSL modem with a DTMD modem, it is an innovation that changes a core design concept without changing the product's architecture.

Semiconductor & Circuit Manufacturing in the US

Define

This industry includes firms engaged in manufacturing semiconductors and related devices and parts. Examples of products within this industry include: integrated circuits, memory chips, microprocessors, diodes, transistors, solar cells and other optoelectronic devices. (IBIS World Industry Report 33441a, July 2010)

Key External Drivers

Private investment in computers and software is a key external driver. Capital funding allows for company start-ups and expansions, ultimately affecting levels of industry production. Fixed private investment into research in the area of semiconductors and other electronics components and end products encourages product innovation and sales growth. The price of semiconductors usually moves in response to global demand/supply trends. Generally, semiconductor prices fall as global economic activity weakens, hence, weakening demand for these components. Downstream demand from electrical equipment, appliance and component manufacturing drives sales in this sector. They typically do not look to the end user to justify demand. The Semiconductor and Circuit Manufacturing industry is affected by the Electronic Goods Manufacturing industry. Growth in demand for electronic goods affects demand for the components that make up the goods. As a result there will be an indirect increase in demand for products from the Semiconductor Manufacturing industry. (IBIS World Industry Report 33441a, July 2010)

Because the industry is heavily reliant on new technologies and innovative product development, investment in research and development helps harness new growth opportunities and drive future industry revenue increases. Gross domestic product (GDP) growth in economic activity affects the demand for infrastructure and industrial machinery, and consumer spending on automobiles, electrical equipment and appliances, telephones and computers. Semiconductors are used by all these sectors, so the demand for industry products will increase in times of strong economic activity. (IBIS World Industry Report 33441a, July 2010)

Potential Impact of DTMD-RADICAL

Semiconductor & Circuit Manufacturing would see DTMD as radical innovation. With DTMD, core concepts and architecture are both overturned for the people who make the chips. DTMD as an innovation forces established organizations of xDSL chipmakers to ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem-solving approaches. DTMD potentially establishes a new dominant design and potentially destroys and old xDSL design based on the use of Discrete Multi-Tone (DMT).

Wired Telecommunications Carriers

Define

Industry participants provide direct communication services, such as local, long distance and international calls, using wireline telecommunications networks. Wired carriers own, operate and maintain this infrastructure, which includes landlines, microwaves and satellite linkups. The industry also includes carriers that provide non-voice telecommunication services, including telegraph. The provision of VoIP, wireless, resale wired and cable TV services are excluded from this industry. (IBIS World Industry Report 51331b, July 2010)

Key External Drivers

Wired carriers are facing intensifying competition from wireless substitutes in a development known as technological substitution. Rapidly falling cell phone prices are making wireless telecommunications a more competitive substitute for wired voice. And the high fixed-cost nature of the wired and wireless businesses is magnifying the impact of this substitution. Wireless carriers are spreading a rapidly expanding subscriber base over a slowly expanding cost base, whereas the opposite is true for wired operators. Consequently, wireless carriers have the capacity to cut prices while wired carriers do not. Another technology substitute is in the form of VoIP. One of the characteristic features of the telecommunications industry in recent years has been the continuous emergence of new technologies, including the likes of naked DSL and VoIP technologies. These developments are weakening demand for the industry: naked DSL because it does not require an internet subscriber to maintain a fixed line and VoIP because it is a price competitive substitute for wired voice. (IBIS World Industry Report 51331b, July 2010)

Potential Impact of DTMD-VARIOUS

***Wired Telecommunications Carriers, who have not invested in system upgrade*-MODULAR**

Wired telecommunications carriers who have not invested in system upgrade would see DTMD as a modular innovation. With DTMD the core concept of the best data rate that is available is overturned, but the architecture remains unchanged. To the degree that one can simply replace a current xDSL modem with a DTMD modem at both the customers' premises and the telephone company central office, it is an innovation that changes a core design concept without changing the product's architecture.

Wired Telecommunications Carriers, invested in Fiber-To-The-Node (FTTN)-ARCHITECTURAL

Wired telecommunications carriers, invested in Fiber-To-The-Node (FTTN) would see DTMD as an architectural innovation. With DTMD core concepts are reinforced, but the architecture of their networking equipment is changed. The essence of the DTMD innovation is the reconfiguration of an established system to link together existing components in a new way. This does not mean that the components themselves are untouched by architectural innovation. The

DTMD architectural innovation is triggered by the replacement of what was the xDSL chip in their components. This change creates a new way of processing the signal and in doing so creates new interactions and new linkages which will now be based on time and code modulation and not frequency and tonal changes. But, they do not change their entire system, just the last mile and they can treat it as an upgrade that has no (or little) associated capital expenditure.

Wired Telecommunications Carriers, invested in FiOS or other forms of Fiber-To-The-Home (FTTH)-RADICAL

Wired telecommunications carriers who are invested in FiOS or other forms of Fiber-To-The-Home (FTTH) would see DTMD as radical innovation. With DTMD, core concepts and architecture are both overturned because it postpones or eliminates the need to take the fiber to consumers' house and no capital expenditure or outside construction is required. DTMD as an innovation forces established organizations of FTTH providers chipmakers to ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem-solving approaches. DTMD potentially establishes a new dominant design and potentially destroys the value of the investment they made in FTTH.

Telecommunication Networking Equipment Manufacturing
Define

This industry manufactures wired (voice and data) telecommunications equipment including: telephone switching systems, telephones and answering machines, data bridges, routers, modems and gateways. During the last ten years, this industry has increasingly relied on data telecommunications and networking equipment manufacturing, which has since made traditional telephone systems obsolete. (IBIS World Industry Report 33421, July 2010)

Key External Drivers

Downstream demand from telecommunications service providers drives sales. Telecommunications carriers, including internet service providers (ISPs), are the main users of this industry's high-end products. The operation and maintenance of networking equipment is an essential production-related capital good for these types of businesses.

Private companies and individuals are major purchasers of networking equipment. For businesses, it is increasingly important to have reliable and speedy internet service throughout the company, especially if they are hosting a website. Companies and consumers will invest in networking equipment in order to achieve these ends. Companies tend to avoid investing in equipment or production capacity when profits are meager or losses are prevalent. During a recession, corporations often defer this kind of investment until the economic climate improves. Corporate profits are generally a leading indicator of activity in this industry and the overall economy. (IBIS World Industry Report 33421, July 2010)

Networking equipment manufacturing is increasingly moving overseas to low-cost countries like China. The relative value of the US dollar against the currencies of its trading partners affects the price competitiveness of products made in the United States and abroad. The higher the US dollar is valued against other currencies, the less competitive US-made products are. Industry systems and technology Internet service providers (ISPs) are major buyers of industry products. When ISPs adopt new technologies, like network-based security or faster connections, they often need to upgrade their networking equipment, boosting revenue for manufacturers. (IBIS World Industry Report 33421, July 2010)

Potential Impact of DTMD- ARCHITECTURAL

Telecommunication networking equipment manufacturers would see DTMD as an architectural innovation. With DTMD core concepts are reinforced, but the architecture of their networking equipment is changed. The essence of the DTMD innovation is the reconfiguration of an established system to link together existing components in a new way. This does not mean that the components themselves are untouched by architectural innovation. The DTMD architectural innovation is triggered by the replacement of what was the xDSL chip in their components. This change creates a new way of processing the signal and in doing so creates new interactions and new linkages which will now be based on time and code modulation and not frequency and tonal changes.

Potential Impact of DTMD on Wired Telecommunications Carriers

1. According to TelePulse, DTMD provides a significant cost advantage compared to other solutions and attempts as shown in Table 2.

DTMD Cost Advantage Over Various Broadband Access Methods

Applications	Fiber to the Home	Fiber to the Curb	Fiber to the Node w/VDSL	HFC (Cable)	DTMD
Variable Costs $/Subscriber	$1,218- $2,617	$1,298- $1,914	$1,272	$2,412	**$600-$700**
Fixed Costs $/Homes Passed or $/CO Customer	$708- $890	$561- $809	$152- $307	$215	**$0**
Total Costs	$1,926- $3,507	$1,859- $2,723	$1,424- $1,579	$2,627	**$600-$700**

Chilson 2002, TelePulse Technologies Corporation

Table 2: DTMD Cost Advantage Over Various Broadband Access Methods

2. The company believes that as demand for greater data rate increases, the Telco/wireline owner can simply increase the number of twisted pairs to meet demand on a per-customer basis. For example: to a distance of 2 miles, customers can get 20Mbps on a single twisted pair; 40Mbps on 2 twisted pairs; 60Mbps on 3 twisted pairs 80Mbps on 4 twisted pairs, 100Mbps on 5 twisted pairs; etc.
3. The company believes that the fiber and fiber enabled solutions require large new infrastructure build-out followed by highly ambitious predictions for market penetration (> 30%). DTMD avoids this cost:
    a. DTMD uses current wireline infrastructure, and its market penetration does not greatly impact cost/subscriber (to 11kft).
    b. To be successful, the other solutions must target entire communities or geographic areas and hope they sign up for the service.
    c. DTMD can target individual customers built upon the traditional wireline architecture. This is critical in rollout to unserved and underserved customers.
    d. Other solutions require many months of very expensive outside construction before the first customer clusters can be served. DTMD installation is functionally very similar to DSL: wireframe connection, card cages and rack of equipment with the same footprint at the Central Office, equal or less power per customer; user line interface and then set top boxes as needed.
    e. With DTMD, each new customer can be set up and served in a few hours.
    f. DTMD is no more difficult to establish than other digital wireline services from a long haul, digitally enabled Central Office. This "middle mile" aggregated high

date rate connectivity has become almost universal to serve both wireline and fiber implemented digital distributions.

4. The company believes that it allows the phone company to target high data rate customers individually rather than by community because it does not require massive expensive infrastructure build out. This keeps the equipment investment costs down and provides the greatest mix of customer types (and needs) without requiring all customers to have the most expensive connectivity and therefore reaches the greatest number of customers.
5. The company believes that phone company decisions on further costly local fiber build out can be moved back 10-20 years. DTMD allows higher data rate services at a third of the price to implement fiber-enabled solutions and a sixth of the price of fiber to the home. This has very large financial benefits to wireline infrastructure owners and users.

What is the "Green-Red" Zone and how to maneuver with it?

Afuah and Bahram describe "The Green-Red Zone Map" (Figure 6) as a simplified two-dimensional version of the hypercube. It is a map of the different faces that an innovation assumes at the different stages of the innovation value-added chain. In the figure, the effect of Innovation A is incremental on suppliers, radical on the innovator, modular on customers, and incremental on complementary innovators. The green zone is where innovations reinforce core concepts, skills and knowledge, and an innovation that falls in this zone for the innovator, supplier, customer and complementary innovators, can be very attractive to the innovating entity.

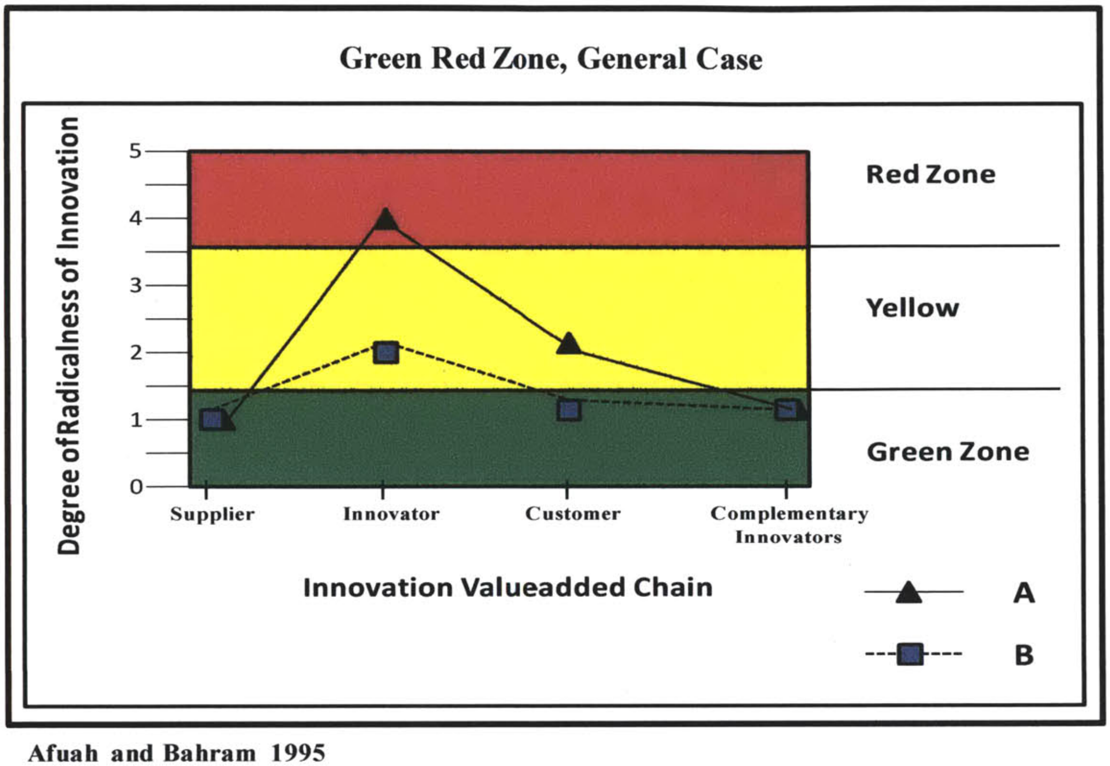


Figure 6: Green-Red Zone, General Case

The red zone covers the area where previous core concepts are overturned, and competence destroyed at the various stages of the chain. This is the zone for radical innovation. According to Afuah and Bahram, any innovation whose map passes through this zone, especially at the customer level, should not be pursued unless a subset of the following is true:

1. The price/performance ratio of the innovation, as viewed by the customer, outweighs any losses incurred as a result of competence or positive network externality destruction. This happens, for example, when the physical limit of an older technological trajectory has been reached and the only way to overcome this physical limitation is to move to a new

technological trajectory - a move that often means destruction of competence acquired during the evolution along the older trajectory but substantial improvement in some key parameter.

2. New markets where customers have not yet had time to build any innovation-specific skills and knowledge, and competence destruction is not an issue.
3. Complementary innovations exist that allow customers to keep their competence and positive network externalities.
4. When institutional requirements mandate the innovation.

Referring again to Figure 6, Innovation A may present the innovator with more problems than Innovation B since A's map along the innovation value-added chain passes through the red zone while B's does not.

With DTMD, the innovators came together to solve a specific problem set. The innovators were not attached to a larger entity; they had no industry investment, or other product/technology sets that were being worked on. Basically, TelePulse can evaluate with the hypercube and use the Afuah and Bahram's four previously mentioned exceptions to maneuver out of the "Red Zones" and down to the "Yellow" or "Green" zones. Now it is time to try this using DTMD. We will score the degree of radicalness of the innovation by the following method:

- Linkages between core concepts & components-un-changed=1 point
- Linkages between core concepts & components-changed=2 points
- Core concepts-reinforced=1 point

- Core concepts-overturned=2 points

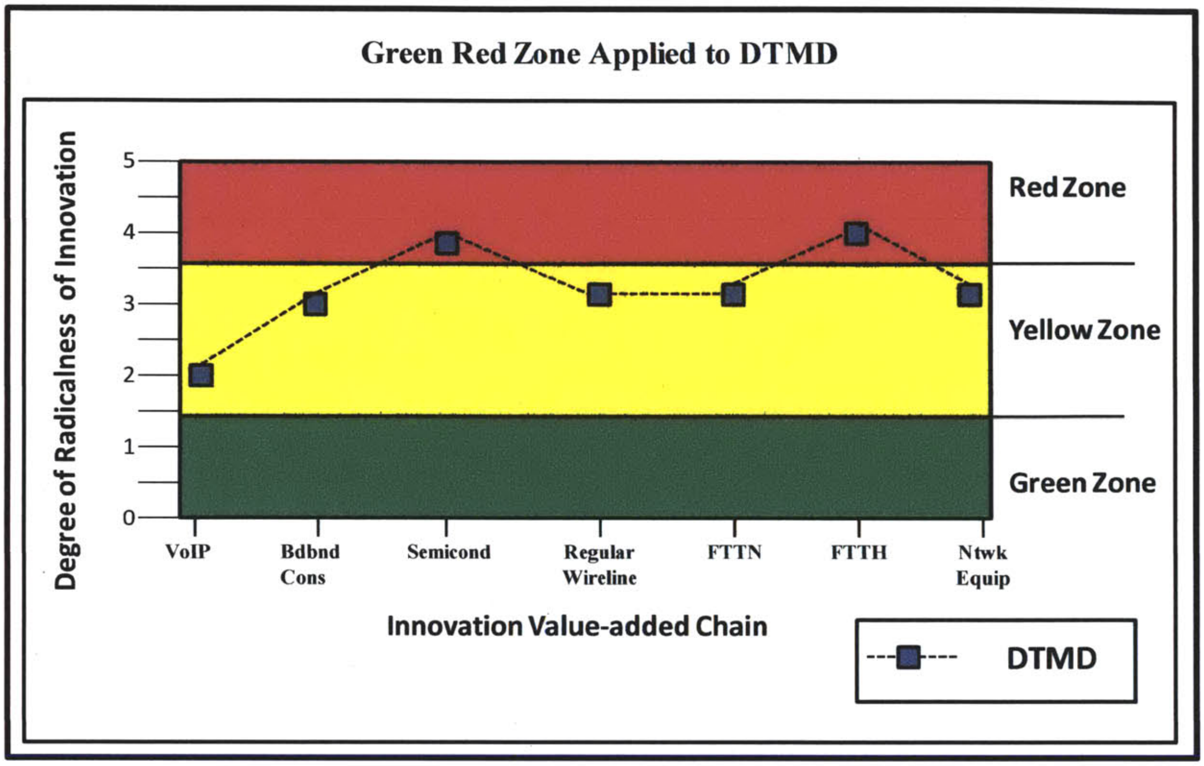


Figure 7: Green Red Zone Applied to DTMD

Figure 7 shows how DTMD scores prior to the use of mitigation. The RED ZONE score for DTMD with semiconductor manufacturers and some of the phone companies would seem to mean that the innovation should not be pursued. So, what could mitigate the degree of radicalness of DTMD?

In order to use the green-red zone map as a way to maneuver we have to have a method for moving our innovation to a point as close as possible to the bottom of the green zone. In other words, we can make the innovation less radical and thus more likely to be pursued. This will be called "mitigation scores". We will use the mitigation scores for the innovation in the following method:

- Innovation gives greater price/performance= -1 point
- Innovation opens new markets= -1 point
- Complementary innovations exist that allow customers to keep their competence and positive network externalities= -1 point
- Innovation mandated by institutional requirements= -1 point

Figure 8 shows the effect of adding this mitigation and how it takes what would be a difficult path to market for innovation and shows how to mitigate the difficulty.

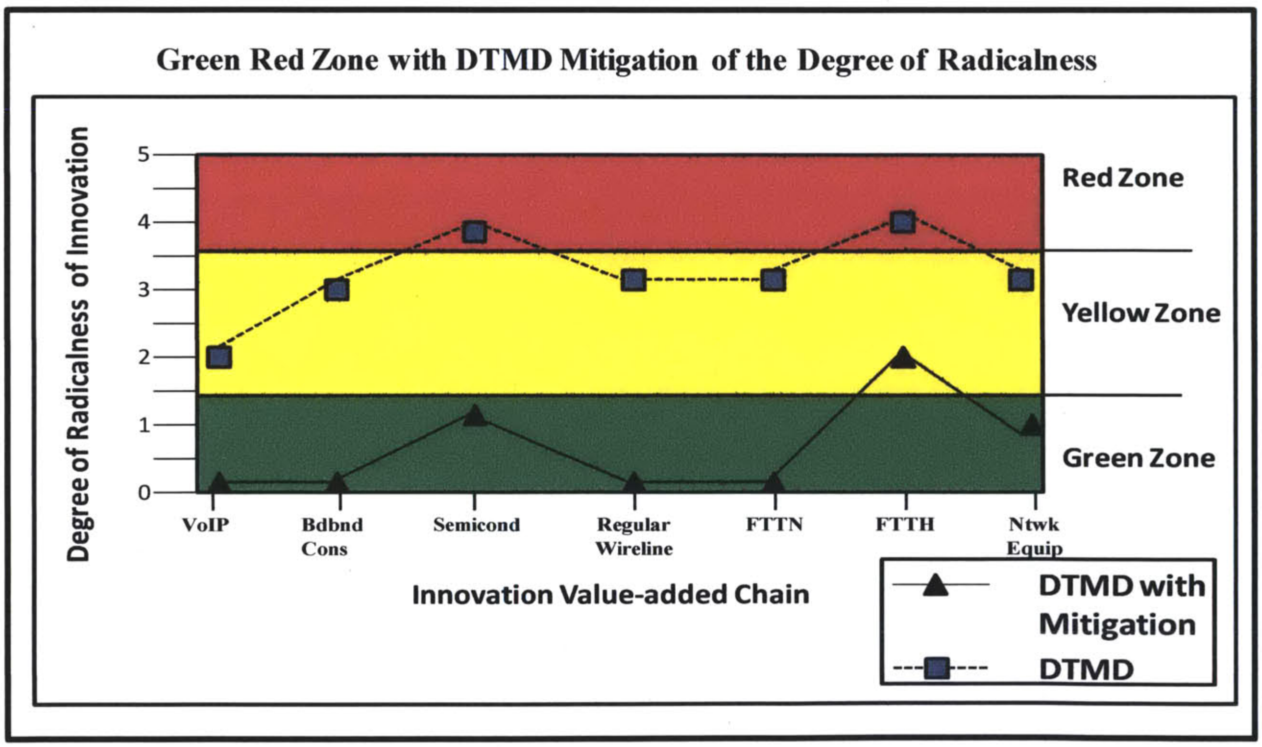


Figure 8: The Green Red Zone with DTMD Mitigation of the Degree of Radicalness

Let's see how the various exceptions used for DTMD play out in the form of mitigation for the value chain elements.

- **Innovation gives greater price/performance= -1 point** In all cases except for FTTH, DTMD would give superior price performance. In the case of FTTH, the price performance increase is an absolute threat to FTTH.

- **Innovation opens new markets= -1 point *DTMD*** opens up new markets of broadband users for regular wireline, VoIP, semiconductor and network equipment. For FTTN, DTMD is complimentary and can be seen as a non-CAPEX upgrade as needed. DTMD can initially target several audiences:
  1. Rural Central Offices where end users are served by copper twisted pair but either their distance from the CO or their low concentration makes the deployment of broadband at 5Mbps or more unfeasible either technologically or economically.
  2. Urban or sub-urban central offices where end users are served by copper twisted pair but their personal economic demographic situation is such that they cannot afford the broadband services at 5Mbps or more that are available around them.

- **Complementary innovations exist that allow customers to keep their competence and positive network externalities= -1 point** For FTTN, broadband consumers, Network Equipment and Regular Wireline, DTMD is essentially plug and play. Remove the xDSL part and replace it with the DTMD part. This is also why for the Network equipment area, they would remove xDSL chips and replace them with DTMD chips. The semiconductor group does not have that luxury. They have to scrap what they have to use DTMD

- **Innovation mandated by institutional requirements= -1 point** The current public policy goals would favor the use of DTMD across the board because the goals of the broadband plan are very aggressive.

This section of the paper analyzed potential disruption in the value chain where DTMD deployment would occur. TelePulse can evaluate value chain impact with the hypercube and use the Afuah and Bahram's green red zone map to maneuver through the value chain elements. Using the hypercube, the paper has shown that the greatest resistance to the technology will come from semiconductor manufacturers and phone companies that have heavily invested in Fiber-To-The-Home (FTTH). According to TelePulse, for the semiconductor manufacturers, they have to contend with the fact that their dominant design is based on xDSL but that the design has a hit a price performance wall that cannot be overcome. Federal policy in the form of the FCCs broadband plan exacerbates this problem because policy is demanding performance that is not achievable by the dominant design. For the FTTH providers they have large capital expenditures in infrastructure and DTMD is faster and cheaper to set up. Long term the FTTH solution, in many cases, offers better price/performance than DTMD but with the high fixed cost it is neither fast nor flexible. TelePulse believes that resistance from these sources can be maneuvered around by:

1. Direct appeal to the regular wireline and Fiber-To-The-Node (FTTN) providers. This will make the purchasers demand the use of the technology independent of the pitch from semiconductor manufacturers.
2. Promoting DTMD as a platform technology more than a product and pursuing licensing opportunities. This allows the semiconductor manufacturer to participate long term and transition to the use of DTMD.

3. Create formal and informal user groups and sell hardware developer kits (HDK). Since the technology will already be promoted as a platform and less as a competitive product, the formal and informal user groups will be a rich source of places for the semiconductor and FTTH groups to innovate based on DTMD. The FTTH pitch will be a long term pitch. DTMD is a signal processing technology that makes the processing significantly more efficient. The FTTH providers can look at the technology as a way to later expand capacity without using capital expenditure.

DTMD Potential Impact on the FCC's National Broadband Plan

According to the Federal Communications Commission (FCC), the mission of the FCC National Broadband Plan is to create a high-performance America—a more productive, creative, efficient America in which affordable broadband is available everywhere and everyone has the means and skills to use valuable broadband applications. The importance of broadband continues to grow around the world. High-performing companies, countries and citizens are using broadband in new, more effective ways. Some countries have recognized this already and are trying to get ahead of the curve. South Korea, Japan, Australia, Sweden, Finland and Germany, among others, have already developed broadband plans. (FCC Broadband Plan, 2010)

In addition to having many recommendations, the plan recommends that the country adopt and track six specific goals to serve as a compass over the next decade. Use of Dynamic Time Metered Delivery (DTMD) potentially has a direct impact on two of these most ambitious goals (FCC Broadband Plan, 2010):

> Goal No. 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.
>
> Goal No. 3: Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

By decreasing the price of broadband performance, DTMD can further FCC goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities. With DTMD and without capital expenditure, the current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current phone lines. For consumers who are relatively close (within 4500ft) to the central office or remote terminal with DTMD and without capital expenditure, consumers can be enabled with a broadband speed of minimum 100Mbps on their current phone lines at a cost 2%-20% of current costs (depending on location). The cost for a phone company to provide the service, in these cases, goes from being a capital expenditure to a consumable expenditure.

Method of the paper

The purpose of this paper is to evaluate the potential impact on the National Broadband Plan of a telecommunications technology called Dynamic Time Metered Delivery (DTMD) using publicly available documents and technical data from TelePulse Technologies Corporation (inventors of the technology). This will be done from the standpoint of public policy and technology strategy as it transforms from a technology offering to become the key component of the first of several useable products. It is important for the reader to note that since there are no DTMD based products currently in use, all discussions of cost and performance are based on TelePulse Technologies Corporation analysis and are by nature forward looking statements. The cost information on competitive technologies is taken from the Chilson Broadband Access Report (Chilson, 2002). I use them because they had the most detailed cost study of access technologies that I could find. The cost information for DTMD is assumed to be the same as that for the various forms of Digital Subscriber Line technology (xDSLor DSL) because the company used xDSL design costs as a design parameter for their design. According to TelePulse, the strategy for DTMD is to make it a plug compatible replacement for xDSL. The needed cost information that for the DTMD costs is a combination of Chilson information and information from

"Implementing ADSL" by David Ginsburg (Ginsburg, 1999) which was used to ensure the cost structure data for xDSL components. This paper concentrates on the technological bottleneck in the final leg of delivering connectivity from a communications provider to a customer, also known as the "last mile" as shown in Figure 9. While the paper provides information on many different access methods, the deeper analysis is with the various forms of digital subscriber line (xDSL) and Fiber-To-The-Home (FTTH), and Fiber-To-The-Node (FTTN). The reason is that two technical aspects are being studied. They are the 100Mbps to 100M household solution and a 5Mbps for everyone solution. The above mentioned fiber based solutions can make the 100Mbps benchmark and xDSL is mentioned because DTMD is a direct replacement for it to get to 100Mbps with and without fiber as well as 5Mbps for everyone. (Chilson, 2002).

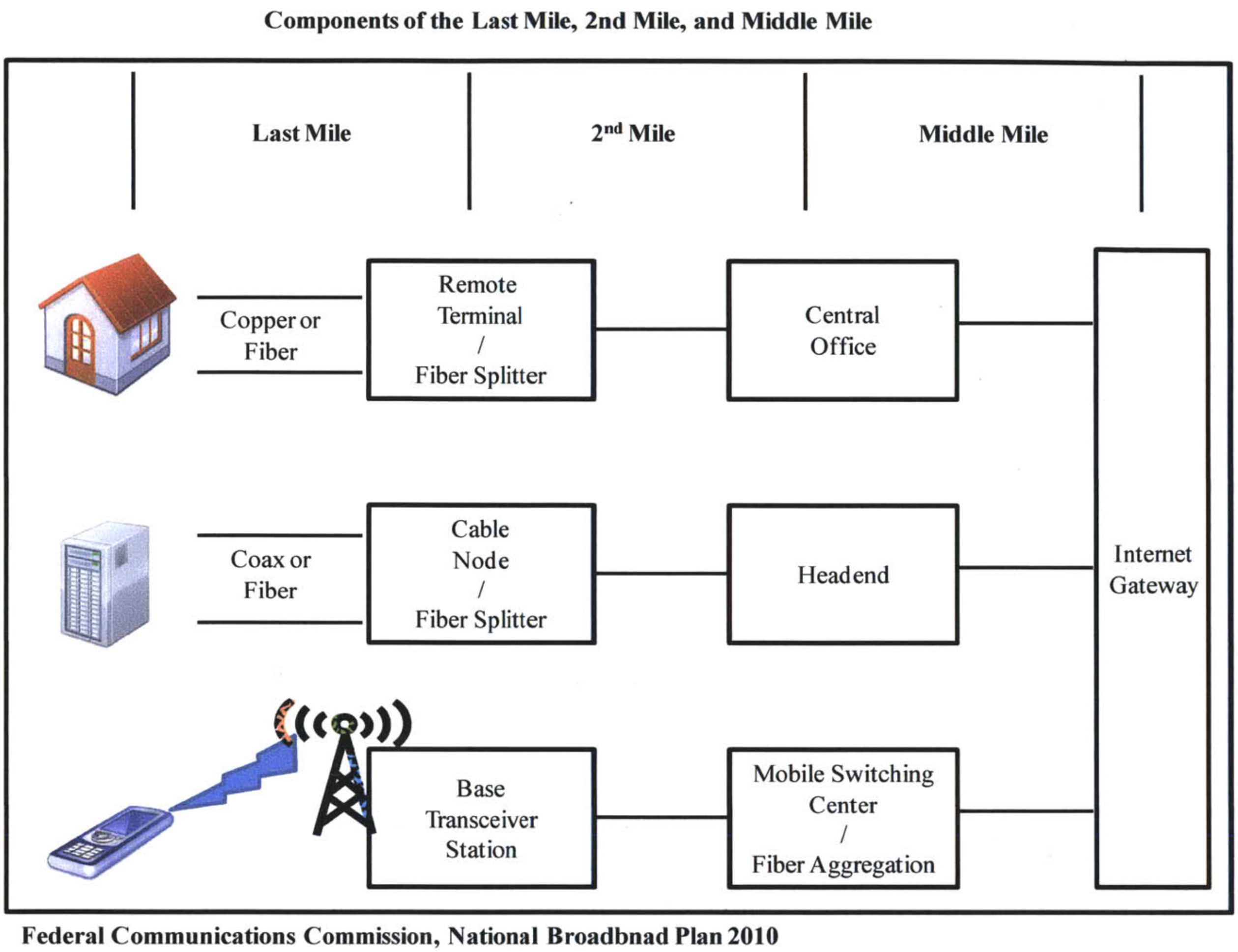
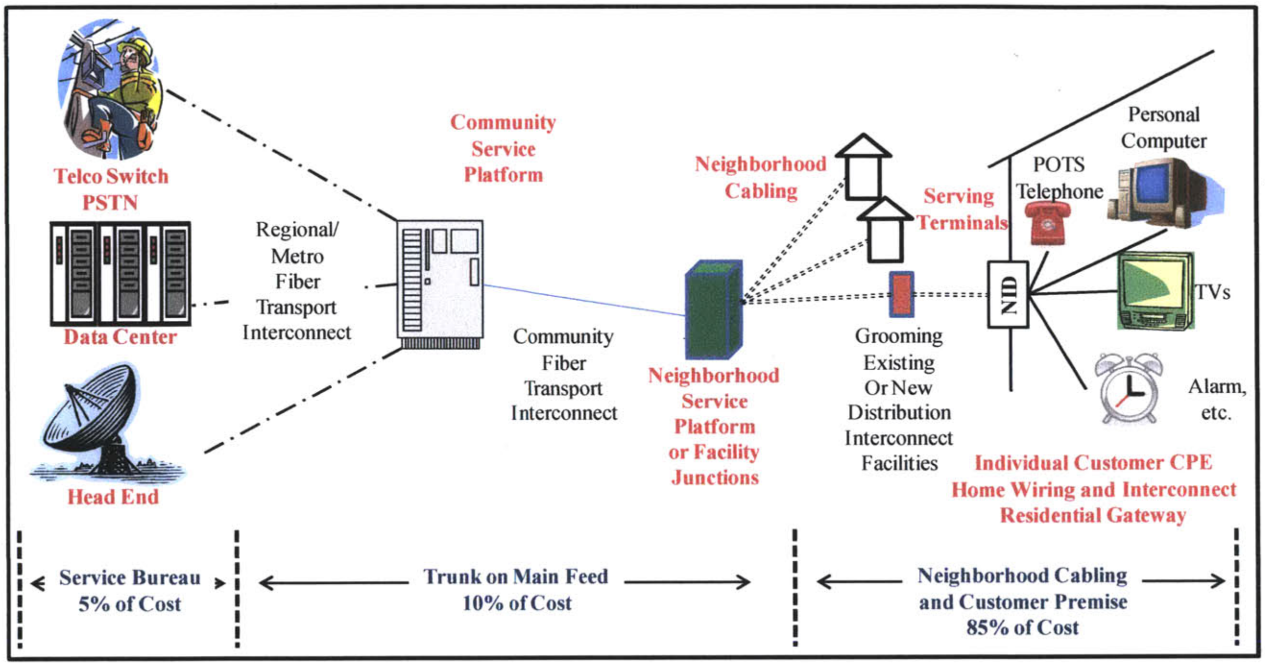


Figure 9: Components of the Last Mile, 2nd Mile, and Middle Mile

Hybrid-Fiber-Coax (HFC) also known as Cable modem is not included because (even in DOCIS 3 configuration) the throughput will not reach 100Mbps average per channel according to Chilson. While HFC can easily provide 5Mbps it is not cost competitive to expand the system to give everyone 5Mbps and have an inability to deliver 100Mbps as shown form the Chilson report. This paper will not evaluate the impact of the increased data flow after the last mile (2nd mile, middle mile, internet gateways, etc.), nor does it consider situations where potential customers do not have phone lines currently installed. The primary reason for this decision is that 85% of the deployment cost is in the last mile according to the Chilson report. This is demonstrated in Figure 10. (Chilson, 2002)

Cost Structures for Providing Broadband Service to a Residence



Chilson (2002)

Figure 10: Cost Structures for Providing Broadband Service to a Residence

On March 16, 2010 the Federal Communications Commission unveiled its "National Broadband Plan." In addition to having many recommendations, the plan recommends that the country adopt and track six specific goals to serve as a compass over the next decade. Use of DTMD potentially has a direct impact on two of these most ambitious goals (FCC Broadband Plan, 2010):

> Goal No. 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.

Goal No. 3: Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

The following data rates are used in this analysis. Prior to July 16, 2010, 768kbps was the FCC definition for basic broadband. If a household could not get 768kbps then they were defined as broadband "un-served". If the FCC minimum was available but they could not get 5Mbps then by FCC standards, they are broadband "underserved". The current definition of unserved, as of July 16, 2010, is 5Mbps (4Mbps up and 1Mbps down). (FCC Sixth Broadband Deployment report 2010)

Achievement of 5Mbps supports real time broadcast quality video. Providing 15Mbps would support either 3 channels of real time broadcast quality video or 1 channel of real time HD quality video (newer compression rates allow for transmission between 15-19 Mbps). 20Mbps will support 1 channel of real time HD quality video or 4 channels of real time broadcast quality video. 50Mbps will support 2 or 3 channels of real time HD quality video or 10 channels of real time broadcast quality video. 100Mbps will support 5 or 6 channels of real time HD quality video or 20 channels of real time broadcast quality video. (FCC Sixth Broadband Deployment report 2010) (Chilson, 2002)

Use of DTMD and the Impact on this Plan

Dynamic Time Metered Delivery (DTMD) can significantly decrease both the necessary cost and time of attaining these goals. If DTMD based equipment becomes commercially available, then planners should be able to decide when and how to build out the supporting fiber infrastructure using cost assessments that include the use of DTMD and knowledge of how many unused twisted pair are available.

For the rural community, the cost of broadband is still going to be comparatively high. However, for the rural community, DTMD is especially attractive because the cost for the basic broadband will be dramatically decreased. With DTMD and without capital expenditure, the current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current lines using a DTMD access multiplexer in the central office and a compatible modem at the customer premises. The decision to provide the service goes from being a capital expenditure to a consumable expenditure The public policy impact is that the technology removes any technological barrier to providing the un-served with broadband. With the July 2010 FCC ruling that made minimum broadband 5Mbps, the full impact of DTMD without capital expenditure (CAPEX) will not be known until the results of the National Broadband Mapping are published. That will then tell us how far everyone is from a central office or remote terminal.

According to TelePulse Technologies Corporation, essentially DTMD generates an infinite number of the possible frequencies that can fit into the wireline's bandwidth (and not just an ordered grouping across that bandwidth) by using both time and code domain encoding. In so doing it achieves significant processing gain. This gain gives DTMD in excess of 10dB advantage with the new implementation over equivalent types of DSL, all things being equal. This benefit can be used several ways: One in data rate by extending the upper limit, another in reach to even more distant customers, and the third in rejection of interferers by that amount. Going to Fiber enabled solutions (FTTH, HFC (Cable), FTTN w/DTMD or FTTN w/VDSL) will be effected by population density. Decisions on going to DTMD based solutions (without

CAPEX, or FTTN w/DTMD) are heavily based on loop length, the distance from the customer to the central office or remote terminal. The basic relationship is shown in Figure 11.

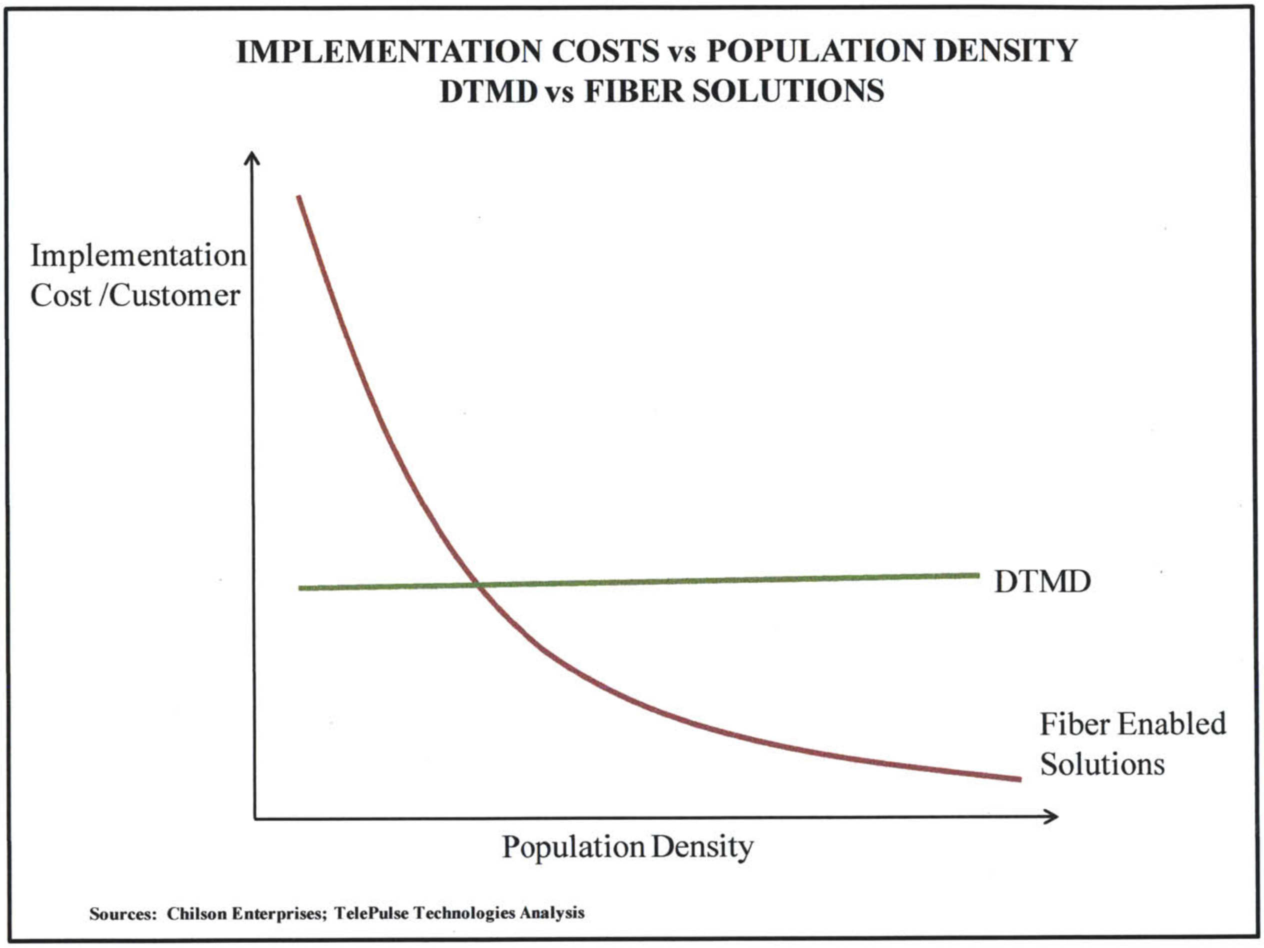


Figure 11: Implementation Costs vs Population Density-DTMD vs. Fiber Solutions

When DTMD is used on current infrastructure, the density of the population has no impact on the cost but it is important to fiber based solutions because of the large up front capital investment needed before the infrastructure can be used. The shared cost of the CAPEX is spread to more participants. Distance is the enemy for DTMD. As the technology is used over a greater distance the signal attenuates. However, the attenuation is only important to cost if the operator is trying to maintain a minimum data rate. In order to get that rate at a longer distance the operator may have to make more lines available to use. This is what increases the cost per household as can be seen in the stair step effect in Figure 12; however the cost per phone line would be unchanged. (Chilson, 2002) (DeFrancesco, 2003)

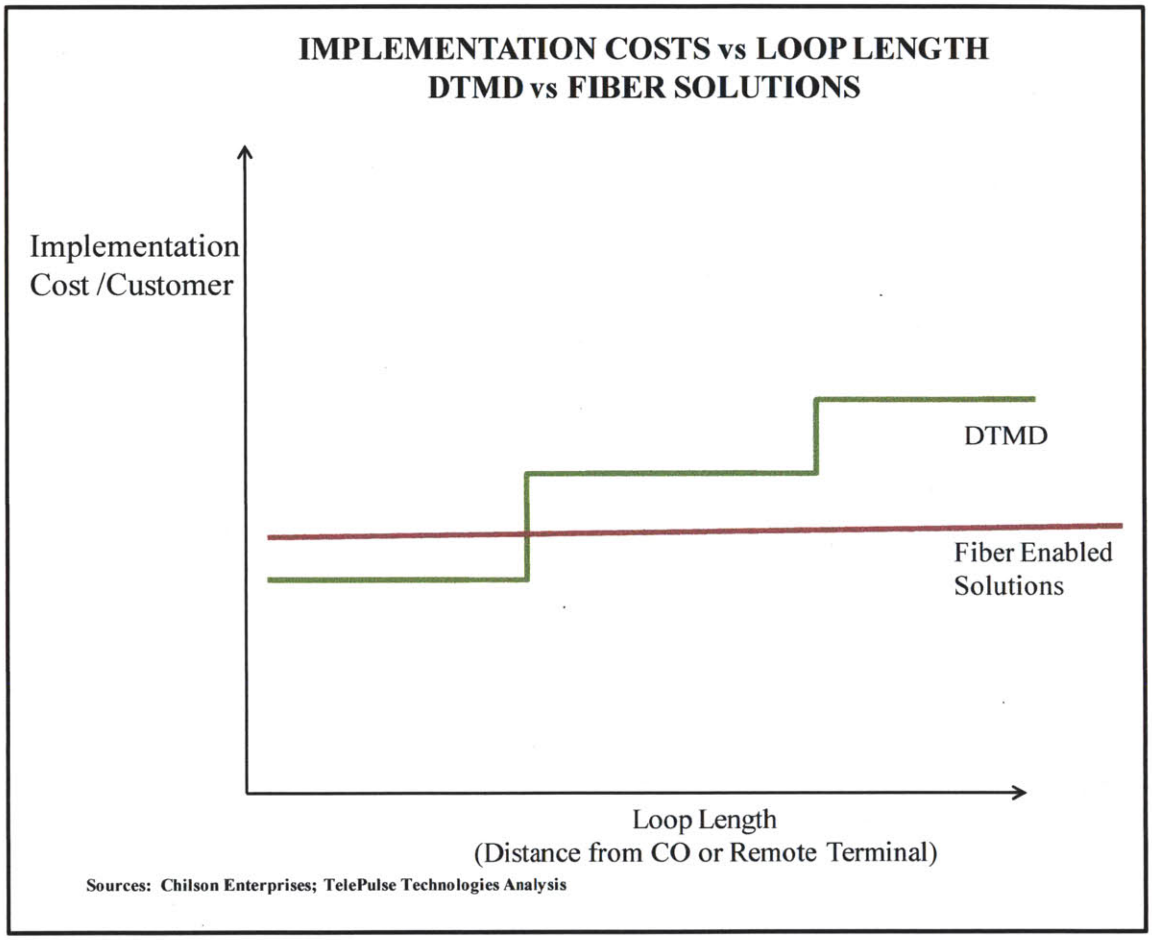
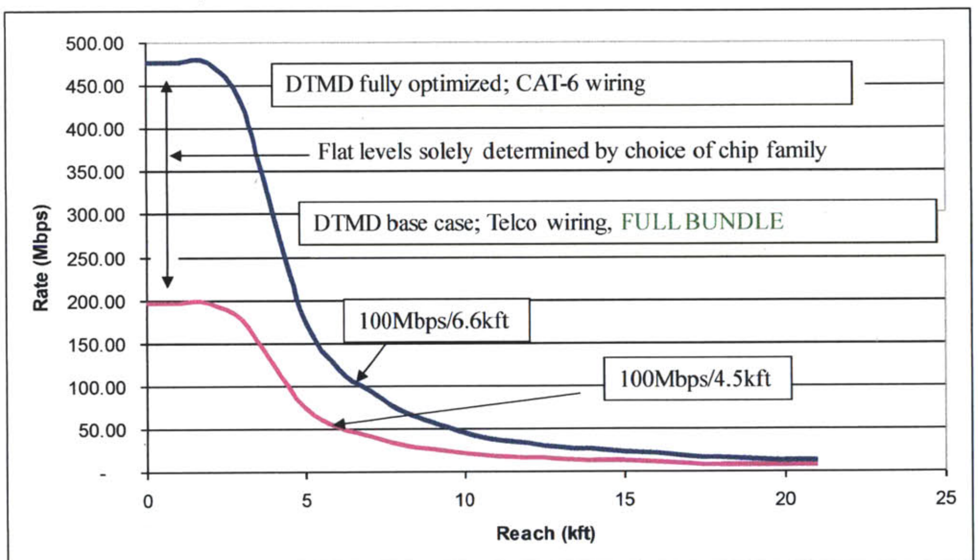


Figure 12: Implementation Costs vs Loop Length-DTMD vs. Fiber Solutions

The vision for the various forms of digital subscriber line (xDSL) technologies was that they would use the current infrastructure to deliver high data rates and avoid costly investment in infrastructure. Dynamic Time Metered Delivery (DTMD) is compatible with xDSL infrastructure, but with the significant increase in processing gain it is not only more efficient but also more flexible. Figure 13 shows the data rates for DTMD. In perfect world with perfect wire the system is fully optimized with CAT-6 wiring and a data rate of at least 100Mbps can be maintained for 6600ft. This is good for all of the wires in the bundle. In a not so perfect world where the wiring has been in use for an indeterminate amount of time and the operator has to use whatever is there, DTMD should maintain a data rate of at least 100Mbps out to only 4500ft. For both the fully optimized case and the base case, DTMD can maintain at least a 5Mbps data rate (FCC minimum broadband) out to a distance of 5 miles or 26,400 ft.

DTMD* Rate vs. Reach Projections



Out to 5 miles customers can get 5Mbps out to 6 miles customers can get 1.5Mbps on a single twisted pair, 3Mbps with 2 twisted pair.

*Note the figures for DTMD are for a single twisted pair. If two pairs are used, then the amount can be doubled, if 4 are used then multiply by 4.

TelePulse Technologies Corporation

Figure 13: DTMD Data Rate vs Reach Projections

Figure 14 shows a head to head comparison on data rate between the base case of DTMD and the best that xDSL has to offer at various distances. The greater data rate for the longer distance can be noted. (Chilson, 2002) (DeFrancesco, 2003)

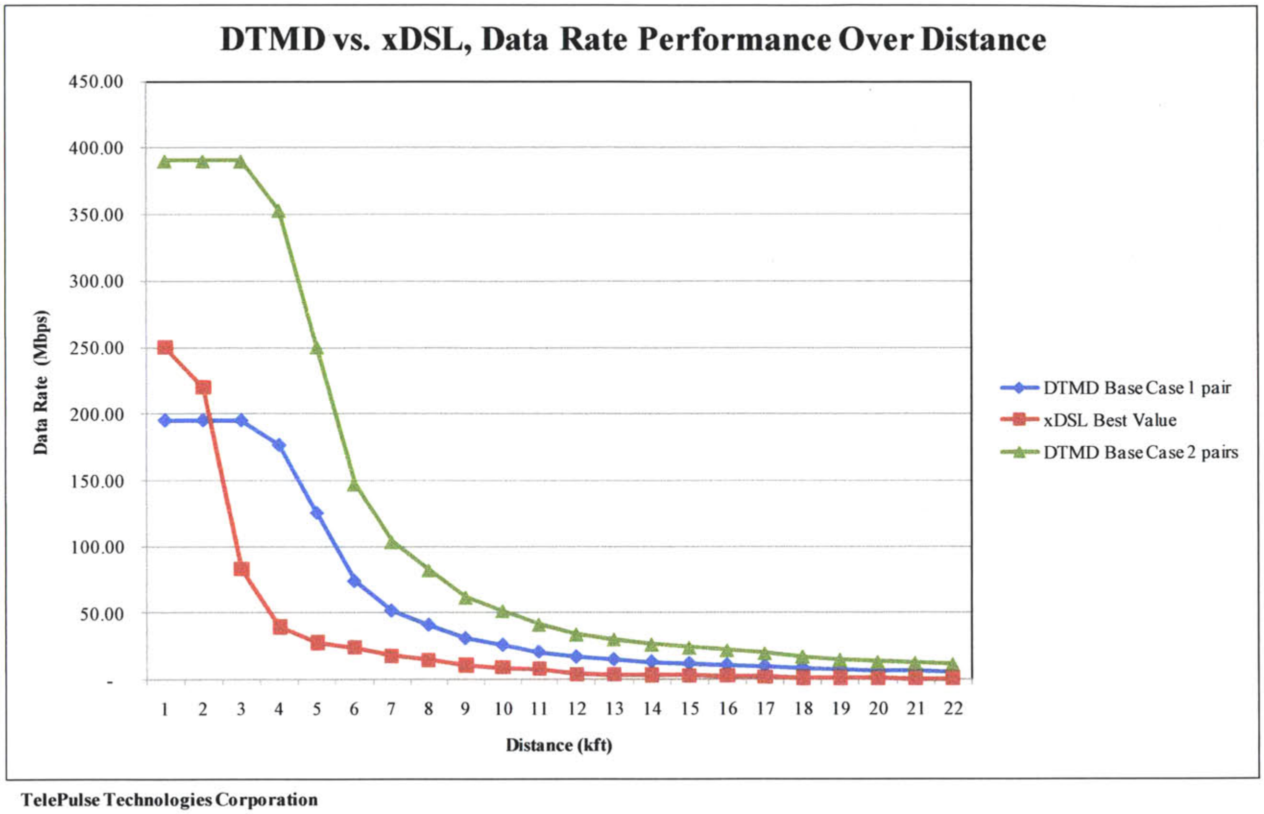


Figure 14: DTMD vs. xDSL, Data Rate Performance Over Distance

But it is also important to note that multiple lines can be easily combined to double, or triple the data rate for a given customer. Because the xDSL signal is generated using Discrete Multi-tone (DMT) it is susceptible to crosstalk. As described in great detail by Star, Cioffi, and Silverman, this crosstalk is related to frequency and inhibits the effective data rate (Starr et al 1999). When wires are combined in a bundle for the phone company, the engineers have to decide to either:

1. Decrease the data rate so that more of the wires can have DSL at a lessened performance. (Bingham, 2000)

2. Increase the data rate for a few customers and only partially fill the wire bundle in order to give a few customers more robust service. This can lead to others being ignored or unreasonably delayed for service, but ultimately the plant is not fully utilized. (Bingham, 2000)

DTMD modulates more by time and code instead of frequency. As a result the entire plant can be fully utilized to maximum capacity (near the Shannon limit). Ultimately what happens is that xDSL can achieve 100Mbps for a few lines out to a distance of 1500 ft while DTMD can deliver to ALL of the lines to a distance of 4500 ft. Additionally, xDSL can achieve 5Mbps for a few lines out to a distance of 10,500 ft while DTMD can deliver to ALL of the line to a distance of 26,000 ft. Deciding whether to use DTMD vs. fiber enabled solutions is basically going to boil down to (Chilson, 2002) (DeFrancesco, 2003):

1. Cost/household
2. Cost ($/Mbps)
3. Distance covered by current infrastructure
4. Population density (current and projected)

Use of DTMD potentially has a direct impact on two of the most ambitious FCC goals:

- **Goal No. 1:** At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.
- **Goal No. 3:** Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

DTMD and Goal No. 1

The FCC believes that the United States must lead the world in the number of homes and people with access to affordable, world-class broadband connections. As such, 100 million U.S. homes should have affordable access to actual download speeds of at least 100 Mbps and actual upload speeds of at least 50 Mbps by 2020. (FCC Broadband Plan, 2010)

According to the FCC, this will create the world's most attractive market for broadband applications, devices and infrastructure. The plan has recommendations to foster competition, drive demand for increased network performance and lower the cost of deploying infrastructure. These recommendations include providing consumers with information about the actual performance of broadband services, reviewing wholesale access policies and conducting more thorough data collection to monitor and benchmark competitive behavior. Government can also help create demand for more broadband by enabling new applications across our most important national priorities, including health care, education and energy, and by ensuring consumers have full control of their personal data. As a milestone, by 2015, 100 million U.S. homes should have affordable access to actual download speeds of 50 Mbps and actual upload speeds of 20 Mbps. (FCC Broadband Plan, 2010)

Impact For Urban Deployment.

Table 3 shows the cost per customer of deploying FTTH in a 100Mbps solution for various take rates (percentage of homes passed that actually take the service). (Chilson, 2002) (DeFrancesco, 2003)

Urban Deployment Costs ($/Household) for 100Mbps Capable Broadband

	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$7,664	$10,736	$3,402	$3,738	$2,899	$2,364
Take Rate of 20%	$4,457	$6,759	$2,362	$2,529	$2,110	$1,843
Take Rate of 30%	$3,388	$5,433	$2,015	$2,126	$1,847	$1,669
Take Rate of 40%	$2,853	$4,770	$1,841	$1,925	$1,715	$1,582
Take Rate of 50%	$2,533	$4,372	$1,737	$1,804	$1,636	$1,529
Take Rate of 60%	$2,319	$4,107	$1,668	$1,724	$1,584	$1,495
Take Rate of 70%	$2,166	$3,918	$1,618	$1,666	$1,546	$1,470
Take Rate of 80%	$2,052	$3,776	$1,581	$1,623	$1,518	$1,451
Take Rate of 90%	$1,963	$3,665	$1,552	$1,589	$1,496	$1,437
Take Rate of 100%	$1,891	$3,576	$1,529	$1,563	$1,479	$1,425
Fixed Cost $/ Household passed	$641	$795	$208	$242	$158	$104

Chilson 2002, TelePulse Technologies Corporation

Table 3: Urban Deployment Costs ($/Household) for 100Mbps Capable Broadband

For a 30% take rate in an urban setting FTTH solution will cost approximately $3400-5400 while using a FTTN scheme with DTMD drops the price to $1700. Table 4 shows the costs in $/Mbps. (Chilson, 2002) (DeFrancesco, 2003)

Urban Deployment Costs ($/Mbps)Per Household for 100Mbps Capable Broadband

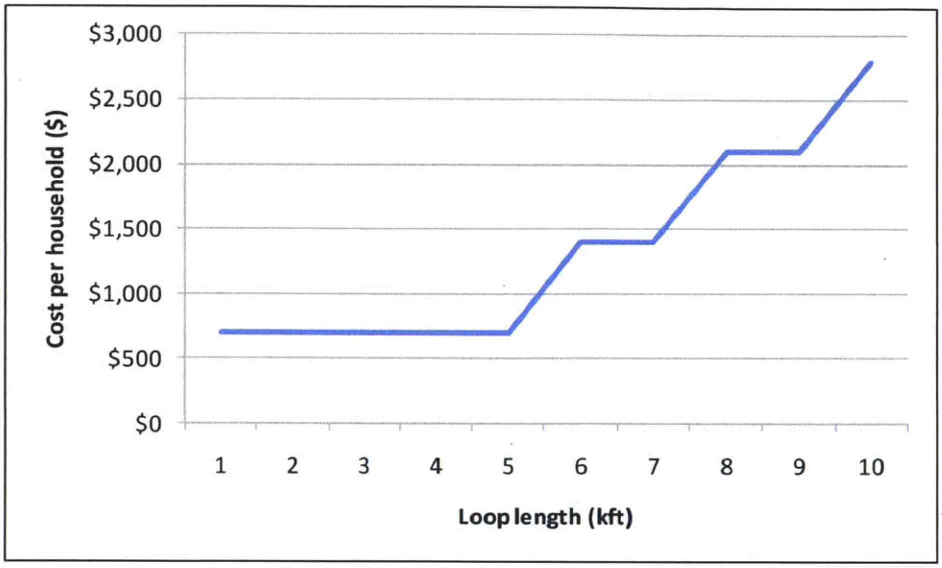
	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$65.71	$11.51	$17.42	$20.10	$16.40	$18.87
Take Rate of 20%	$38.22	$7.24	$12.09	$13.60	$11.94	$14.71
Take Rate of 30%	$29.05	$5.82	$10.32	$11.43	$10.45	$13.32
Take Rate of 40%	$24.46	$5.11	$9.43	$10.35	$9.70	$12.63
Take Rate of 50%	$21.72	$4.69	$8.89	$9.70	$9.25	$12.20
Take Rate of 60%	$19.88	$4.40	$8.54	$9.27	$8.96	$11.93
Take Rate of 70%	$18.57	$4.20	$8.28	$8.96	$8.75	$11.73
Take Rate of 80%	$17.59	$4.05	$8.10	$8.73	$8.59	$11.58
Take Rate of 90%	$16.83	$3.93	$7.95	$8.54	$8.46	$11.47
Take Rate of 100%	$16.21	$3.83	$7.83	$8.40	$8.37	$11.37
Fixed Cost $/ Household passed	$5.50	$0.85	$1.07	$1.30	$0.89	$0.83

Chilson 2002, TelePulse Technologies Corporation

Table 4: Urban Deployment Costs ($/Mbps) Per Household for 100Mbps Capable Broadband

Figure 15 shows DTMD costs of deployment without CAPEX for 1,2,3, and 4 twisted pairs. (Chilson, 2002) (DeFrancesco, 2003)

DTMD Implementation Cost ($/per Household) at 100Mbps on Current Infrastructure



Chilson 2002, TelePulse Technologies Corporation

Figure 15: DTMD Implementation Cost ($/per Household) at 100Mbps on Current Infrastructure

Figure 16 brings together the information as ($/Mbps) in a way that encompasses the cost of extra lines and attenuation over distance. (Chilson, 2002) (DeFrancesco, 2003)

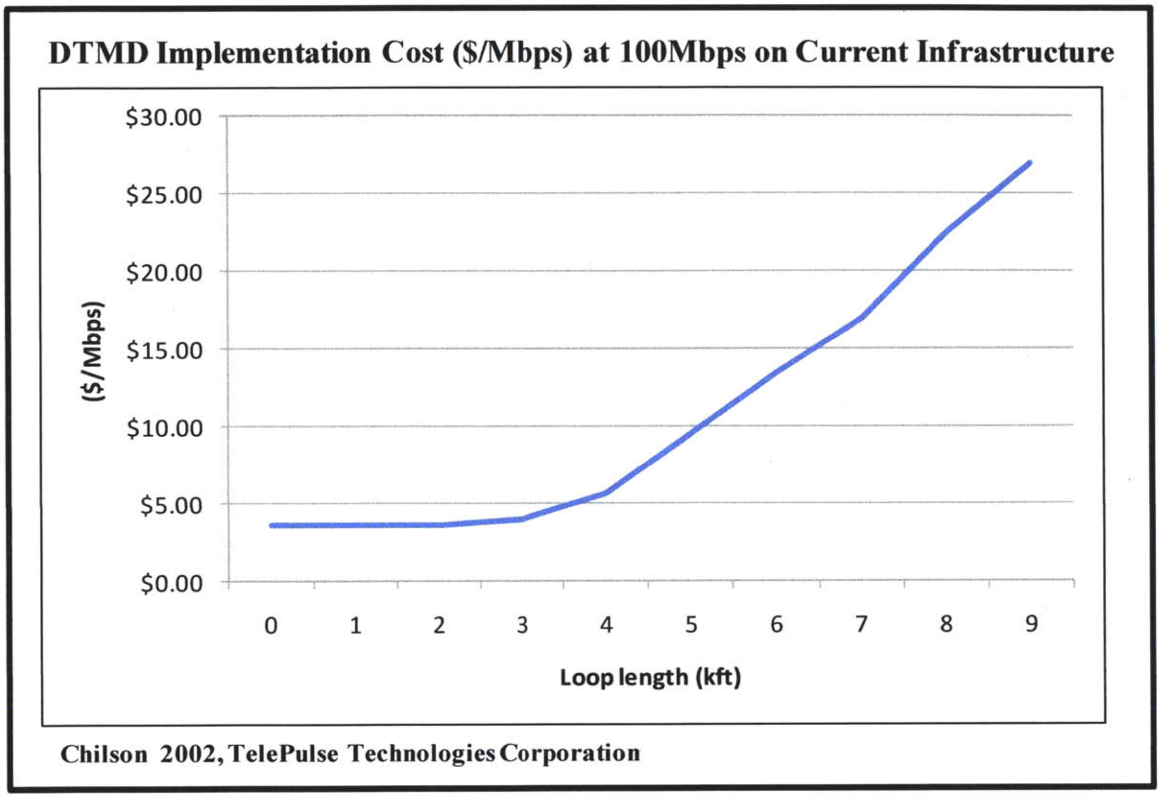


Figure 16: DTMD Implementation Cost ($/Mbps) at 100Mbps on Current Infrastructure

With DTMD, a customer in the first 4500 ft from the central office or remote terminal the cost is $700. From 4500-6000 ft the cost is $1400 and requires 2 twisted pairs. At this point there may or may not be extra available unused twisted pairs. If there are extra pairs then, for customers 6000-7500 ft away the cost would be $2100. But, if consumer adoption is high enough (take rate at least 30%) then at this point the CAPEX to invest in FTTN w/DTMD makes sense at a cost of $1700 with a 30% take rate. (Chilson, 2002) (DeFrancesco, 2003)

Impact For Suburban Deployment.

Table 5 shows the cost per customer of deploying FTTH in a 100Mbps solution for various take rates (percentage of homes passed that actually take the service). (Chilson, 2002) (DeFrancesco, 2003)

Suburban Deployment Costs ($/Household) for 100Mbps Capable Broadband

	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$11,289	$16,840	$7,692	$6,930	$5,983	$3,171
Take Rate of 20%	$6,336	$9,305	$4,488	$4,108	$3,634	$2,228
Take Rate of 30%	$4,686	$6,793	$3,421	$3,167	$2,851	$1,914
Take Rate of 40%	$3,860	$5,537	$2,887	$2,696	$2,460	$1,757
Take Rate of 50%	$3,365	$4,784	$2,567	$2,414	$2,225	$1,662
Take Rate of 60%	$3,035	$4,282	$2,353	$2,226	$2,068	$1,600
Take Rate of 70%	$2,799	$3,923	$2,200	$2,092	$1,956	$1,555
Take Rate of 80%	$2,622	$3,654	$2,086	$1,991	$1,872	$1,521
Take Rate of 90%	$2,485	$3,444	$1,997	$1,912	$1,807	$1,495
Take Rate of 100%	$2,375	$3,277	$1,926	$1,850	$1,755	$1,474
Fixed Cost $/ Household passed	$990	$1,507	$641	$564	$470	$189

Chilson 2002, TelePulse Technologies Corporation

Table 5: Suburban Deployment Costs ($/Household) for 100Mbps Capable Broadband

For a 30% take rate in a suburban setting FTTH solution will cost approximately $4700-$6800 while using a FTTN scheme with DTMD drops price to $1900. Table 6 shows the costs in $/Mbps. (Chilson, 2002) (DeFrancesco, 2003)

Suburban Deployment Costs ($/Mbps) for 100Mbps Capable Broadband

	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$96.80	$18.05	$39.39	$37.26	$33.85	$25.31
Take Rate of 20%	$54.33	$9.97	$22.98	$22.09	$20.56	$17.78
Take Rate of 30%	$40.18	$7.28	$17.52	$17.03	$16.13	$15.28
Take Rate of 40%	$33.10	$5.93	$14.78	$14.49	$13.92	$14.02
Take Rate of 50%	$28.85	$5.13	$13.14	$12.98	$12.59	$13.27
Take Rate of 60%	$26.02	$4.59	$12.05	$11.97	$11.70	$12.77
Take Rate of 70%	$24.00	$4.20	$11.26	$11.25	$11.07	$12.41
Take Rate of 80%	$22.48	$3.92	$10.68	$10.70	$10.59	$12.14
Take Rate of 90%	$21.31	$3.69	$10.23	$10.28	$10.22	$11.93
Take Rate of 100%	$20.36	$3.51	$9.86	$9.95	$9.93	$11.76
Fixed Cost $/ Household passed	$8.49	$1.62	$3.28	$3.03	$2.66	$1.51

Chilson 2002, TelePulse Technologies Corporation

Table 6: Suburban Deployment Costs ($/Mbps) for 100Mbps Capable Broadband

Impact For Rural Deployment.

Figure 25 shows the cost per customer of deploying FTTH in a 100Mbps solution for various take rates (percentage of homes passed that actually take the service). (Chilson, 2002) (DeFrancesco, 2003)

Rural Deployment Costs ($/Household) for 100Mbps Capable Broadband

	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$88,090	$156,417	$104,786	$104,786	$104,786	$95,195
Take Rate of 20%	$44,758	$79,682	$53,036	$53,036	$53,036	$48,240
Take Rate of 30%	$30,314	$54,104	$35,785	$35,785	$35,785	$32,588
Take Rate of 40%	$23,092	$41,315	$27,160	$27,160	$27,160	$24,763
Take Rate of 50%	$18,759	$33,642	$21,985	$21,985	$21,985	$20,067
Take Rate of 60%	$15,870	$28,526	$18,535	$18,535	$18,535	$16,937
Take Rate of 70%	$13,807	$24,872	$16,071	$16,071	$16,071	$14,701
Take Rate of 80%	$12,259	$22,132	$14,223	$14,223	$14,223	$13,024
Take Rate of 90%	$11,055	$20,000	$12,785	$12,785	$12,785	$11,720
Take Rate of 100%	$10,093	$18,295	$11,635	$11,635	$11,635	$10,676
Fixed Cost $/ Household passed	$8,666	$15,347	$10,350	$10,350	$10,350	$9,391

Chilson 2002, TelePulse Technologies Corporation

Table 7: Rural Deployment Costs ($/Household) for 100Mbps Capable Broadband

For a 30% take rate in a rural setting FTTH solution will cost approximately $30,000-$54,000 while using a FTTN scheme with DTMD produces a price of $33,000. Table 8 shows the costs in $/Mbps. (Chilson, 2002) (DeFrancesco, 2003)

Rural Deployment Costs ($/Mbps) for 100Mbps Capable Broadband

	FTTH 32:1	FTTH 4:1	FTTN w/DTMD 2.0 kft	FTTN w/DTMD 2.5kft	FTTN w/DTMD 3.0 kft	FTTN w/DTMD 4.0 kft
Take Rate of 10%	$755.33	$167.65	$536.54	$563.37	$592.78	$759.80
Take Rate of 20%	$383.78	$85.40	$271.56	$285.14	$300.03	$385.03
Take Rate of 30%	$259.93	$57.99	$183.23	$192.39	$202.44	$260.10
Take Rate of 40%	$198.00	$44.28	$139.07	$146.02	$153.65	$197.65
Take Rate of 50%	$160.85	$36.06	$112.57	$118.20	$124.37	$160.16
Take Rate of 60%	$136.08	$30.57	$94.91	$99.65	$104.85	$135.18
Take Rate of 70%	$118.39	$26.66	$82.29	$86.40	$90.91	$117.34
Take Rate of 80%	$105.11	$23.72	$72.83	$76.47	$80.46	$103.95
Take Rate of 90%	$94.79	$21.44	$65.46	$68.74	$72.33	$93.54
Take Rate of 100%	$86.54	$19.61	$59.58	$62.55	$65.82	$85.21
Fixed Cost $/ Household passed	$74.31	$16.45	$53.00	$55.65	$58.55	$74.95

Chilson 2002, TelePulse Technologies Corporation

Table 8: Rural Deployment Costs ($/Mbps) for 100Mbps Capable Broadband

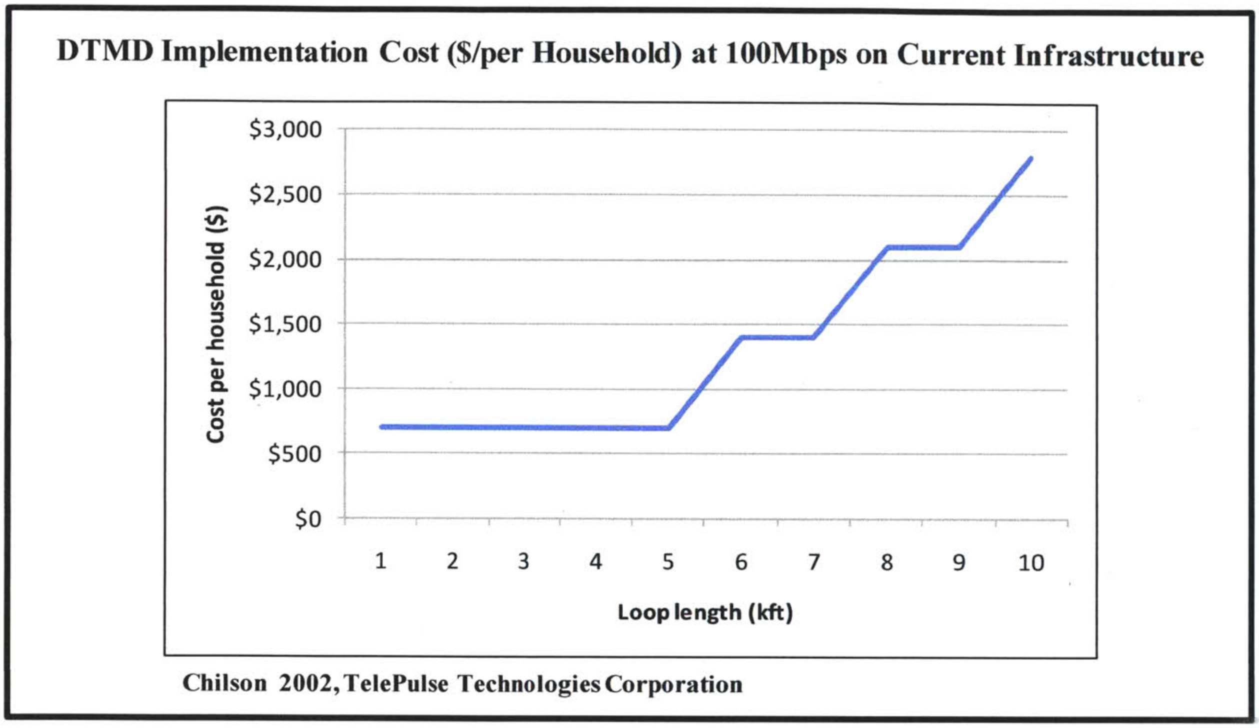


Figure 17: DTMD Implementation Cost ($/per Household) at 100Mbps on Current Infrastructure

Figure 17 shows DTMD costs of deployment without CAPEX for 1,2,3, and 4 twisted pairs. Figure 18 brings all of the information in one chart. From here it can be seen that the cost of getting to a 100Mbps solution for FTTH (assuming a 30% take rate) is $30,000-$54,000. With DTMD, a customer in the first 4500 ft from the central office or remote terminal the cost is $700. From 4500-6000 ft the cost is $1400 and requires 2 twisted pairs. At this point there may or may not be extra available unused twisted pairs. If there are extra pairs then, for customers 6000-7500 ft away the cost would be $2100. But, even if expected consumer adoption is as high as 100% there is still a gap from $2100 to $11,000 that is impossible to ignore. Unless the loop lengths for these areas are shorter, or the population density increases it is unlikely that they will be able to participate in a 100Mbps solution. (Chilson, 2002) (DeFrancesco, 2003)

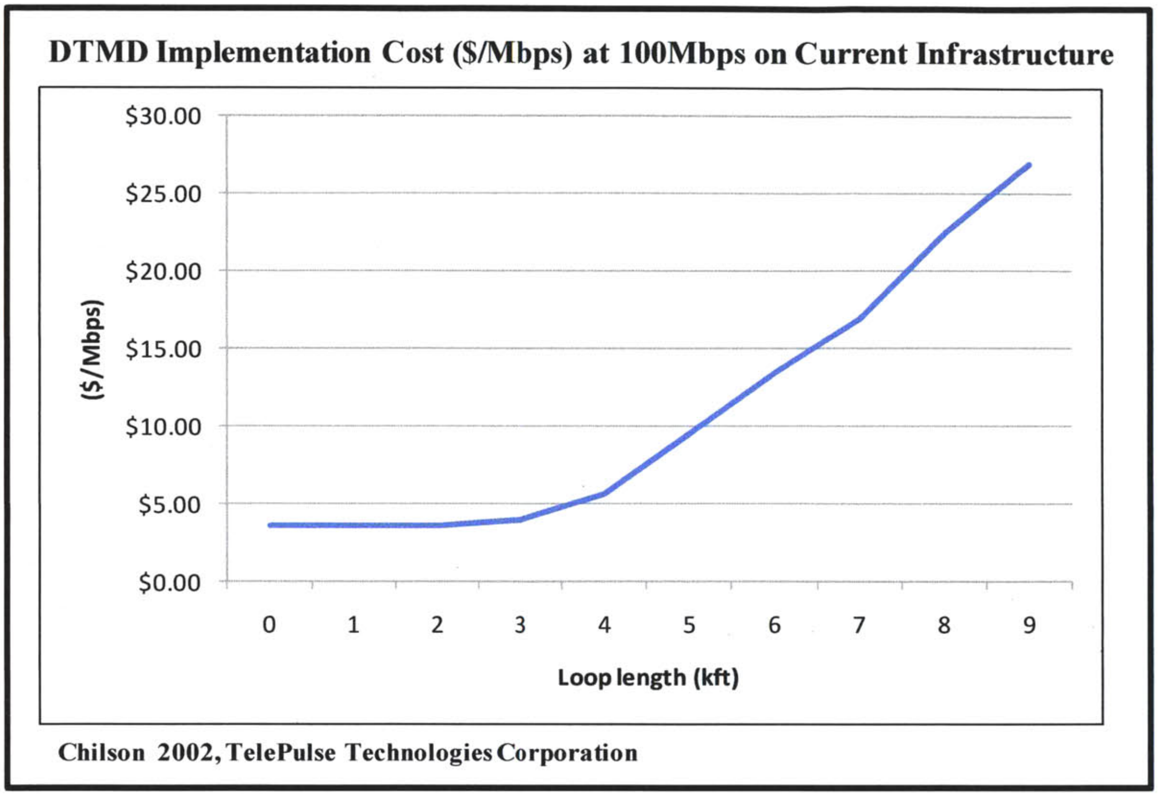


Figure 18: DTMD Implementation Cost ($/Mbps) at 100Mbps on Current Infrastructure

By allowing 100Mbps to a distance of 4500 ft on a single twisted pair, on current infrastructure, for all of the wires in the wire bundle, with no CAPEX, DTMD can take the cost of attaining this 100Mbps goal down to approximately $700/twisted pair used from approximately $3400-$5400 per household in urban settings, $4700-$6800 per household in suburban settings, and $30,000-$54,000 in rural settings. If a broadband provider has already deployed FTTN w/xDSL then DTMD can be seen as an upgrade that still decreases the cost per consumer and cost in $/Mbps. At a data rate of 100M the only other solution is to use FTTH. (Chilson, 2002) (DeFrancesco, 2003)

DTMD and Goal No. 3

Use of DTMD potentially has a direct impact on Goal No. 3: The FCC believes every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose. According to the FCC, not having access to broadband applications limits an individual's ability to participate in 21st century American life. Health care, education and other important aspects of American life are moving online. What's more, government services and democratic participation are shifting to digital platforms. This plan recommends government use the Internet to increase its own transparency and make more of its data available online. Getting everyone online will improve civic engagement—a topic this plan also addresses by recommending a more robust digital public ecosystem. (FCC Broadband Plan, 2010)

Three requirements must be satisfied to ensure every American can take advantage of broadband. First, every American home must have access to network services. Second, every household should be able to afford that service. Third, every American should have the opportunity to develop digital skills. (FCC Broadband Plan, 2010)

The plan recommends reforming existing support mechanisms to foster deployment of broadband in high-cost areas: specifically, the Universal Service Fund and inter-carrier compensation. The plan outlines a 10-year, three-stage course of action to transform these programs to connect those who do not have access to adequate broadband infrastructure. Rather than add new burdens to the already strained contribution base, we must make the tough choice to shift existing support that is not advancing public policy goals in order to directly focus those resources on communities unserved by broadband. (FCC Broadband Plan, 2010)

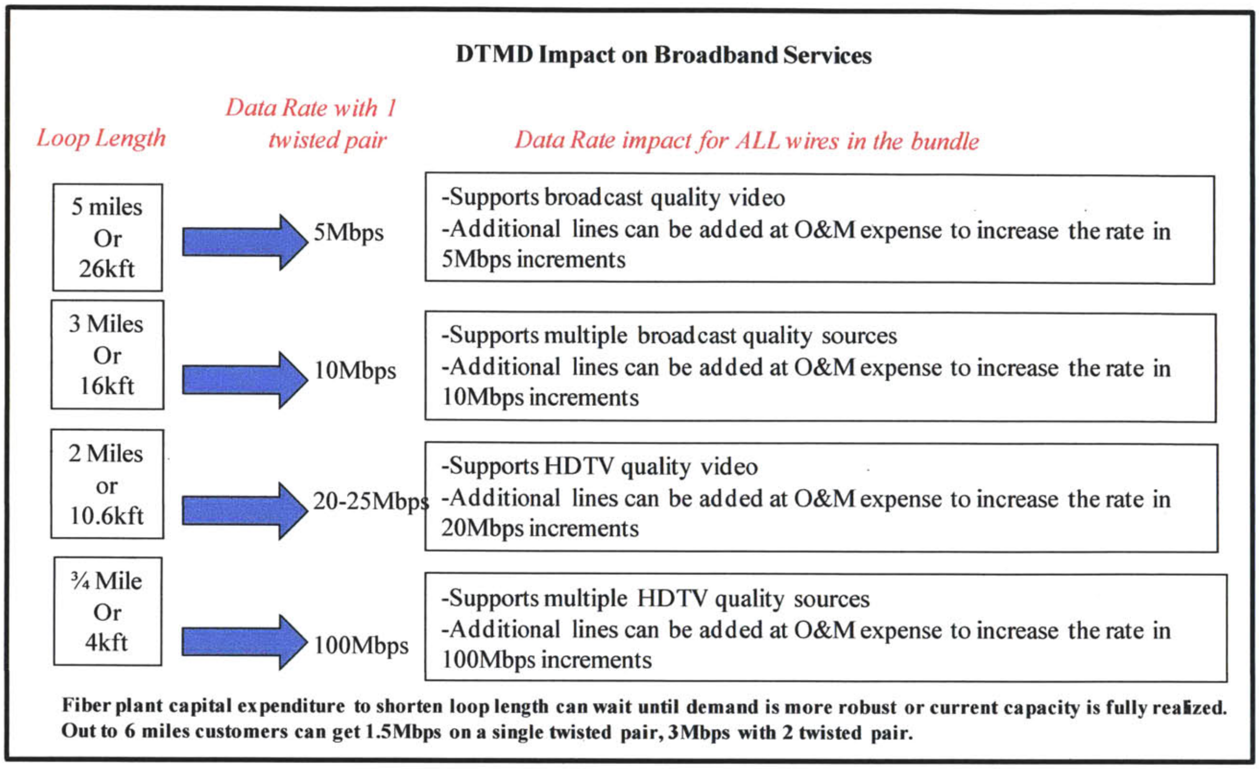
To promote affordability, this plan also proposes extending the Lifeline and Link-Up programs to support broadband. To promote digital skills, we need to ensure every American has access to relevant, age-appropriate digital literacy education, for free, in whatever language they speak, and we need to create a Digital Literacy Corps. (FCC Broadband Plan, 2010)

The FCC believes that achieving this goal will likely lead to an adoption rate higher than 90% by 2020 and reduced differences in broadband adoption among demographic groups. To this end, government can make broadband more accessible to people with disabilities. It can also work with Tribal governments to finally improve broadband deployment and adoption on Tribal lands. And it can ensure small businesses—many of which are owned by women and minorities—have the opportunity to purchase broadband service at reasonable rates. (FCC Broadband Plan, 2010)

According to Bingham and Telecordia, 85% of the US phone lines are loops of 18kft or less (Bingham, 2000). So, with no CAPEX, for roughly $700, on a single twisted pair, all 100 million can have 7.5Mbps which is greater than the 5Mbps FCC benchmark for "un-served." If DTMD based equipment becomes commercially available, then planners should be able to decide when and how to build out the supporting fiber infrastructure using cost assessments that include the use of DTMD and knowledge of how many unused twisted pair are available. A second twisted pair will get a total of 15Mbps. Three twisted pair gets 22.5Mbps and 4 twisted pair gets 30Mbps. Depending on the number of available unused phone lines and expectations of further usage in the service area, fiber buildout should happen at the point where there is demand for greater than 20Mbps. At that point the fiber build out should be to 4k loops with 100-125Mbps at around $1,500/household assuming 30%-60% take rates. (Chilson, 2002) (DeFrancesco, 2003)

Figure 17 shows examples of services available at various data rates for various lengths.

- 5Mbps -Supports broadcast quality video, additional lines can be added at O&M expense to increase the rate in 5Mbps increments (Chilson, 2002) (DeFrancesco, 2003)
- 10Mbps-Supports multiple broadcast quality sources, additional lines can be added at O&M expense to increase the rate in 10Mbps increments (Chilson, 2002) (DeFrancesco, 2003)
- 20-25Mbps -Supports HDTV quality video, or at least 5 channels of broadcast quality video, additional lines can be added at O&M expense to increase the rate in 20Mbps increments. 100Mbps-Can support 2 HDTV quality sources or 5 broadcast quality sources, additional lines can be added at O&M expense to increase the rate in 100Mbps increments (Chilson, 2002) (DeFrancesco, 2003)



TelePulse Technologies Corporation

Figure 19: DTMD Impact on Broadband Services

From the simple non-CAPEX addition of DTMD, a minimum of 85% of the current lines can support broadcast quality video, additional lines can be added at O&M expense to increase the rate in 5Mbps increments. (Chilson, 2002) (DeFrancesco, 2003)

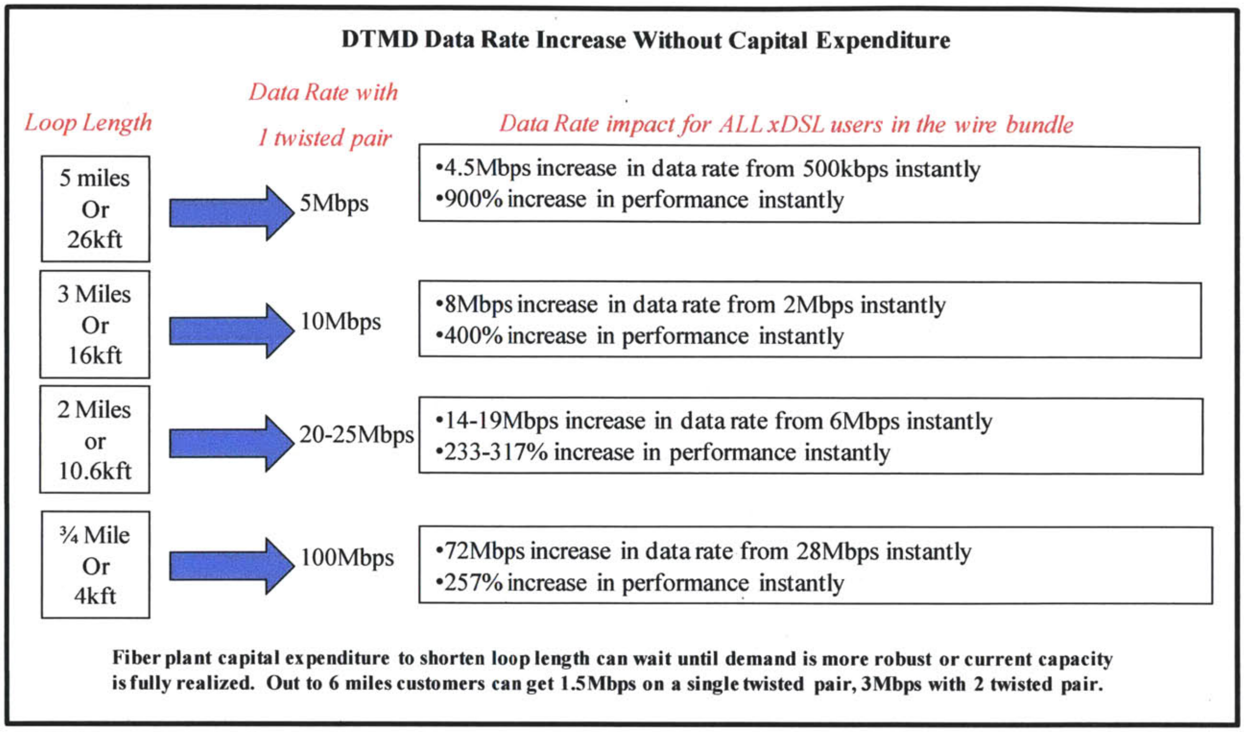


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Figure 20: DTMD Data Rate Increase Without Capital Expenditure

Figure 18 shows examples of the kind of data rate increases that can be available immediately with DTMD. (Chilson, 2002) (DeFrancesco, 2003) Customers out to a distance of:

- 5 miles or 26kft can experience a 4.5Mbps increase in data rate from 500kbps instantly. This is a 900% increase in performance instantly.
- 3 miles or 16kft can experience an 8Mbps increase in data rate from 2Mbps instantly. This is a 400% increase in performance instantly
- 2 miles or 10.6kft can experience a 14-19Mbps increase in data rate from 6Mbps instantly This is a 233-317% increase in performance instantly.

- ¾ or 4kft can experience a 72Mbps increase in data rate from 28Mbps instantly. This is a 257% increase in performance instantly

TelePulse believes that use of TelePulse Technologies DTMD can have a significant impact on the National Broadband Plan. With the technology advantages being best determined by distance from the central office, the results of the State Broadband Data and Development Program, also known as the Broadband Mapping Program, are of great interest. The Recovery Act directed National Telecommunications and Information Administration (NTIA) to develop and maintain a comprehensive nationwide inventory map of broadband service capability and availability, and to make the map publicly available via the Internet. NTIA is in the process of awarding grants to all 50 states, 5 territories, and the District of Columbia, or their designees, to collect and verify statewide data about the availability, speed, and location of broadband Internet. This data collection is to be conducted on a semi-annual basis over a two-year period, with the data to be presented in a clear and accessible format to the public, government, and the research community. NTIA will use the data collected by grantees, in combination with other data sources, to create and publish online the National Broadband Map by February 17, 2011. This program will give more accurate information on loop lengths and give a better idea of even greater advantages for DTMD. TelePulse Technologies believes that TelePulse DTMD combined with the mapping program is important to the efforts of the Broadband Plan because (Chilson, 2002) (DeFrancesco, 2003):

1. DTMD provides a significant cost advantage end-to-end as shown in Table 9.

DTMD Cost Advantage Over Various Broadband Access Methods					
Applications	**Fiber to the Home**	**Fiber to the Curb**	**Fiber to the Node w/VDSL**	**HFC (Cable)**	**DTMD**
Variable Costs $/Subscriber	$1,218- $2,617	$1,298- $1,914	$1,272	$2,412	**$600-$700**
Fixed Costs $/Homes Passed or $/CO Customer	$708- $890	$561- $809	$152- $307	$215	**$0**
Total Costs	$1,926- $3,507	$1,859- $2,723	$1,424- $1,579	$2,627	**$600-$700**

Chilson 2002, TelePulse Technologies Corporation

Table 9: DTMD Cost Advantage Over Various Broadband Access Methods

2. As demand for greater bandwidth increases the telco can simply increase the number of twisted pairs to meet demand on a per/customer basis. For example: to a distance of 2 miles customers can get 20Mbps on a single twisted pair; 40Mbps on 2 twisted pairs; 60Mbps on 3 twisted pairs 80Mbps on 4 twisted pairs, 100Mbps on 5 twisted pairs; etc.

   a. The fiber and fiber enabled solutions require large new infrastructure build-out followed by highly ambitious predictions for market penetration (> 30%).

   b. DTMD uses current infrastructure, and its market penetration does not greatly impact cost/subscriber (to 11kft).

   c. To be successful, the other solutions must target entire communities or geographic areas and hope they sign up for the service.

   d. DTMD can target individual customers

   e. Other solutions require many months of outside construction before the first customer clusters can be served.

f. With DTMD, each customer can be set up and served in a few hours.

3. Allows the phone company to target high bandwidth customers individually rather than by community because it does not require infrastructure build out.

4. Decisions on further fiber buildout can be moved back 10-20 years. DTMD allows higher data rate services at 1/3 of the price to implement fiber-enabled solutions and 1/6 of the price of fiber to the home. This has very large financial benefits to wireline infrastructure owners and users especially those in disbursed rural areas, multi-tenant units, and underserved low income areas.

5. It allows phone companies to achieve a triple play (voice, data and video to the level of HDTV quality) to a distance of 2 miles on a single twisted pair for ALL wires in the wire bundle at a cost 1/3 to 1/6 of the price of current fiber-enabled solutions.

For the rural community, the cost of 100Mbps broadband is still going to be comparatively high. However, for the rural community, DTMD is especially attractive because the cost for the basic broadband has dramatically decreased compared to what is found in urban areas (depending on distance). With DTMD and without capital expenditure, the 14-24M current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current lines using a DTMD access multiplexer in the central office and a compatible modem at the customer premises. The decision to provide the service goes from being a capital expenditure to a consumable expenditure The public policy impact is that the technology removes any technological barrier to providing the un-served with broadband. (Chilson, 2002) (DeFrancesco, 2003)

Bringing Potentially Disruptive Innovation and Telecom Infrastructure Together

What is the effect of Dynamic Time Metered Delivery (DTMD) in the achievement of the Federal Communications Commission's "National Broadband Plan"? In answering this question it was necessary to bring potentially disruptive innovation together with technology policy. Essentially, Afuah and Bahram's hypercube can have public sector telecommunications policy as part of the chain. Other questions that have to be answered include:

- Why might the private sector ignore FCC driven investment opportunities and incentives to innovate in areas where DTMD has a clear price/performance advantage?
- Why might these private and public sector goals be in conflict?

In the case of broadband deployment, for rural communities, less dense suburban communities and low income urban communities, private sector business goals and public sector goals may conflict because the FCC had public sector goal of ubiquitous broadband and the private sector has financial goals of return on investment and low risk. (FCC Broadband Plan, 2010) Additionally, various parts of broadband provider's value chain may see needed innovation as potentially disruptive, lacking a robust total market, or lacking a high degree of interest by the service provider (the perceived driver of market volume). While private sector investment in broadband has increased, that funding is focused on more at improving current investment with incremental improvement to market proven technologies. (FCC Broadband Plan, 2010) FCC driven investment opportunities and incentives to innovate for the unserved should include opportunities to innovate with technologies that are not fully market proven but can potentially address both private and public sector goals. Otherwise the private sector incentive will be to continue squeezing returns from their large current infrastructure investment and avoiding unprofitable customers on the fringe. A technology like DTMD, can help in bringing the private and public goals together because it can potentially make the broadband ubiquity goals of the FCC financially achievable (or even attractive) for the private sector. (Chilson, 2002) (FCC Broadband Plan, 2010) (DeFrancesco, 2003)

Conclusion

The Federal Communications Commission (FCC) has stated that broadband is the great infrastructure challenge of the early 21st century. In order to meet the policy challenge, on March 16, 2010, the FCC published "Connecting America: The National Broadband Plan." This paper has examined the potential use of a new technology called Dynamic Time Metered Delivery (DTMD) in the furtherance of the broadband plan goals using data and analysis from public sources and TelePulse Technologies Corporation (inventors of DTMD). DTMD is a signal processing technology that is first being applied to copper based networks due to the current need for price performance enhancement over what is available with the various forms of Digital Subscriber Line (xDSL) technology. For a given distance that data has to travel, DTMD allows either more data to travel the same distance or the same amount of data to travel a much longer distance, and variations in between. It can also be used through a variety of transmission media including coaxial cable, fiber optic, powerline and wireless RF, Optical and Acoustic signals. The key questions answered by the research paper are:

- Using Hypercube analysis, how would key elements of the value chain for phone companies categorize and react to DTMD as an innovation?
- Are there specific goals of the FCC National Broadband Plan that might be directly furthered by the use of DTMD?

Using Hypercube Analysis, the paper analyzed potential disruption in the value chain where DTMD deployment would occur. Various parts of a broadband provider's value chain may see needed innovation as potentially disruptive, lacking a robust total market, or lacking a high degree of interest by the broadband service provider (the perceived driver of market volume).The paper has shown that the greatest resistance to a technology such as DTMD will come from semiconductor manufacturers and broadband service providers that have heavily invested in Fiber-To-The-Home (FTTH). According to TelePulse, for the semiconductor manufacturers, they have to contend with the fact that their dominant design is based on xDSL but that the design has a hit a price performance wall that cannot be overcome. Federal policy in the form of the FCCs broadband plan exacerbates this problem because policy is demanding performance that is not achievable by the dominant design. For the FTTH providers they have large capital expenditures in infrastructure and DTMD is faster and cheaper to set up. Long term the FTTH solution, in many cases, offers better price/performance than DTMD but with the high fixed cost it is neither fast nor flexible. Resistance from these sources can be maneuvered around by:

1. Direct appeal to the regular wireline and Fiber-To-The-Node (FTTN) providers. This will make the purchasers demand the use of the technology independent of the pitch from semiconductor manufacturers.
2. Promoting DTMD as a platform technology more than a product and pursuing licensing opportunities. This allows the semiconductor manufacturer to participate long term and transition to the use of DTMD.
3. Create formal and informal user groups and sell hardware developer kits (HDK). Since the technology will already be promoted as a platform and less as a competitive product, the formal and informal user groups will be a rich source of places for the semiconductor and FTTH groups to innovate based on DTMD. The FTTH pitch will be a long term pitch. DTMD is a signal processing technology that makes the processing significantly more efficient so its use is not restricted to copper based

networking. The FTTH providers can look at the technology as a way to later expand capacity without using capital expenditure (CAPEX).

Use of DTMD has a potential direct impact on two of the FCC's National Broadband Plan goals. Specifically:

- Goal No. 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.
- Goal No. 3: Every American should have affordable access to robust broadband service (5Mbps), and the means and skills to subscribe if they so choose.

By decreasing the price of broadband performance, DTMD can further FCC goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities. With DTMD and without capital expenditure (CAPEX), the current broadband un-served can be enabled with a broadband speed of minimum 5Mbps on their current phone lines. The cost for a phone company to provide the service goes from being a capital expenditure to a consumable expenditure.

By decreasing the price of broadband performance, DTMD can further FCC goals for broadband adoption in rural communities, less dense suburban communities and low income urban communities. By allowing 100Mbps to a distance of 4500 ft on a single twisted pair, on current infrastructure, for all of the wires in the wire bundle, with no CAPEX, DTMD can take the cost of attaining this 100Mbps goal down to approximately $700/twisted pair used from approximately $3400-$5400 per household in urban settings, $4700-$6800 per household in suburban settings, and $30,000-$54,000 in rural settings. If a broadband provider, using Digital

Subscriber Line (xDSL) has already deployed Fiber-To-The-Node (FTTN) w/xDSL then DTMD can be seen as an upgrade that still decreases the cost per consumer and cost in $/Mbps. At a data rate of 100M the only other solution is to use Fiber-To-The-Home (FTTH), which costs significantly more. Figure 21 summarizes these findings.

Summary of Broadband Access Implementation Costs Based on Take Rate

URBAN

Take Rate (%)	FTTH 32:1	FTTH 4:1	FTTN w/xDSL up to 4.0kft	FTTN w/DTMD up to 4.0kft	No CAPEX DTMD 4.5 kft	No CAPEX DTMD 26 kft
Data Rate(Mbps)	**100Mbps**	**900Mbps**	**33Mbps**	**125Mbps**	**100Mbps**	**5Mbps**
30%	***$3,388***	***$5,433***	***$1,669-$2,015***	***$1,669-$2,015***	***$700***	***$700***
50%	$2,533	$4,372	$1,529-$1,737	$1,529-$1,737	$700	$700
100%	$1,891	$3,576	$1,425-$1,529	$1,425-$1,529	$700	$700

SUBURBAN

Take Rate (%)	FTTH 32:1	FTTH 4:1	FTTN w/xDSL up to 4.0kft	FTTN w/DTMD up to 4.0kft	No CAPEX DTMD 4.5 kft	No CAPEX DTMD 26 kft
Data Rate(Mbps)	**100Mbps**	**900Mbps**	**33Mbps**	**125Mbps**	**100Mbps**	**5Mbps**
30%	***$4,686***	***$6,793***	***$1,914-$3,421***	***$1,914-$3,421***	***$700***	***$700***
50%	$3,365	$4,784	$1,662-$2,567	$1,662-$2,567	$700	$700
100%	$2,375	$3,277	$1,474-$1,926	$1,474-$1,926	$700	$700

RURAL

Take Rate (%)	FTTH 32:1	FTTH 4:1	FTTN w/xDSL up to 4.0kft	FTTN w/DTMD up to 4.0kft	No CAPEX DTMD 4.5 kft	No CAPEX DTMD 26 kft
Data Rate(Mbps)	**100Mbps**	**900Mbps**	**33Mbps**	**125Mbps**	**100Mbps**	**5Mbps**
30%	***$30,314***	***$54,104***	***$32,588-$35,785***	***$32,588-$35,785***	***$700***	***$700***
50%	$18,759	$33,642	$20,067-21985	$20,067-21985	$700	$700
100%	$10,093	$18,295	$10,676-$11,635	$10,676-$11,635	$700	$700

Chilson Enterprises "Broadband Access Report"; TelePulse Technologies-Data Rate is the maximum offered data rate for residential customers
xDSL-Varous forms of Digital Subscriber Line Technology; CAPEX Capital Expenditure;
FTTH-Fiber –To-The-Home; FTTC-Fiber-To-The-Curb; FTTN-Fiber-To-The-Node
Take Rate=Percentage of those who can have access o the service that actually take the service
Take Rate of 30% is used because it is conservative and was the basis of planning before FTTH was actually deployed.
Take Rate of 50% is currently being used for business development planning by many companies

Figure 21 : Summary of Broadband Access Implementation Costs Based on Take Rate

In the case of broadband deployment, for rural communities, less dense urban communities and low income urban communities, private sector business goals and public sector goals conflict. Private sector business goals and public sector goals conflict because the FCC has a public sector goal of ubiquitous broadband and the private sector has financial goals of return on investment and low risk. While private sector investment in broadband has increased, that funding is focused more on improving current investment with incremental improvement to market proven technologies. FCC driven investment opportunities and incentives to innovate for the unserved should include opportunities to innovate with technologies that are not fully market proven market proven but can potentially address both private and public sector goals. Otherwise the private sector incentive will be to continue squeezing returns from their large current infrastructure investment and avoiding unprofitable customers on the fringe. A technology like DTMD, can help in bringing the private and public goals together because it can potentially make the broadband ubiquity goals of the FCC financially achievable (or even attractive) for the private sector. (Chilson, 2002) (FCC Broadband Plan, 2010) (DeFrancesco, 2003)

Specific Areas for Further Research

We have examined Dynamic Time Metered Delivery (DTMD) as an application used on copper wire. It is important to remember that DTMD is not a copper technology; it is a signal processing technology being applied to a copper infrastructure. Further research and analysis should concentrate on using the processing gain of DTMD in Broadband over Powerline, remote utility monitoring, and low cost upgrade for copper based middle mile infrastructure. With fiber networks, DTMD can offer processing gain, but research would have to determine the nature and significance of that potential gain. Doing these types of analysis would give policy planners a much fuller range of infrastructure expansion options. Since the economics of expanding fiber networks is driven by population density and DTMD can be either a non-CAPEX system upgrade or a fiber enabled upgrade; there is uncertainty and risk in expansion related to projections of population growth. This also presents research opportunities. If DTMD based equipment becomes commercially available, then the endpoint of the research opportunities could be twofold:

3. The design of telecommunications infrastructure upgrades using “Real Options” that include the use DTMD.
4. Use of Lessard's RAT's (Relevant, Appropriable and Transferable) test to examine the global growth possibilities and target market for the technology.

Long term, DTMD will be a platform technology. The company would rather license the technology to others who have a need for data rate enhancement for their particular applications or can access niche markets with telephone equipment. The US market has opportunities for rural communities, suburban communities with low population density and urban areas with lower income customers who cannot be profitably served with conventional broadband technology. Opportunities for these types of markets are not relegated to the US. Afuah, Lessard, and Real Options can help us promote the technology to a global audience.

Real Options starts with an assumption that it is best to deal with uncertainty proactively, by building flexibility into the project. From a design perspective, this involves thinking of a project with real options features that enable the managers of a product (owners, systems designers, or other) to provide flexibility to reconfigure a project, to expand it, to change its function, or to alter its operations.

In the final section of the Hypercube paper by Afuah and Barham they discuss areas of future research. They state that they have developed the hypercube model using qualitative data. An area of further research would be the collection of quantitative data to gain further insights to this concept. The second and equally important area of research according to Afuah and Barham would be the extension of the hypercube to include multi-innovator/competitor scenarios. Such an expanded model could then be applied to innovation-based international competition. (Afuah and Bahram, 1995)

The founders of the Hypercube used it for private sector activities but there are opportunities to more fully use the analysis by including include regulatory and public sector, and transnational players.

Lessard's RAT's test addresses the extent to which business models developed in one country effectively travel to others. Lessard's RAT's (Relevant, Appropriable and Transferable) tests the potential to exploit existing competencies internationally examines the global growth possibilities and target market status from the following points:

- R – Relevant- Are there similar customers, tastes, appeal? Are there similar business channels?
- A – Appropriate-Do we have access to/power with channels, advisors who can assist with market entry? Will what we have to offer be valued?
- T –Transferable-Have we done it before? Can the current organization support? Do we have the competencies?

These three conditions which make up the RATs test will determine whether the original capability platform of any firm can travel well regionally or internationally. It is important to notice that they are country specific. That is, the capability platform of a particular company may pass the RATs test for a given country but not for another. In addition to passing the RATs test, firms soon discover whether internationalization for them is an imperative, a possibility or a distant trap.

Lessard's RATs assesses market entry; real options shows how to position DTMD (in various product forms) to help the customer decrease the effects of uncertainty while expanding broadband infrastructure; Afuah and Bahram's Hypercube(expanded with cubes for regulatory and public sector, and transnational players) analyzes the effect on the value chain of various aspect of the broadband infrastructure. These three sets of analytical tools can make for a robust analysis of places where the technology can add the most value.

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