

**Woodfin's Wavelength  
The Video Environment**

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Telcos worldwide are entering the video business in a big way, and the competitive market in the US is poised to get much more complicated. Cable and direct broadcast satellite (DBS) have been battling it out for several years, and smaller telcos have been making various forays into video service deployment. Recent years have seen the major Regional Bell Operating Companies (RBOC) entering into joint marketing alliances with DBS. In addition, BellSouth and Qwest each have existing wireline video service offerings, albeit operating over significantly different network infrastructures. All eyes in the US, though, are now on the impending rollout of video services by Verizon and SBC. SBC is planning what is arguably the world's largest TV over Internet Protocol (IPTV) deployment to-date, to launch some time in 2006 mainly over a copper from the node (CFTN) infrastructure with deployments over fiber to the home (FTTH) in Greenfield application. Verizon's plans call for video to be deployed initially using the familiar radio frequency (RF) technology used by Cable TV operators, but carried over much higher bandwidth FTTH lines rather than coaxial cable. Verizon seems to see a role for IPTV in future plans as well. The resulting competitive impact on the US video market, and the perception of consumers to the various new services planned, will be creating interesting market dynamics.

What will the major new entrants bring to the table? Most knowledgeable observers agree that the average consumer is much more concerned with breadth and quality of services that enter the home, and nearly oblivious to how the services get there. The underlying video technologies and network infrastructures, however, are key to determining what can be offered today and in the future.

The average number of TVs per home in the US is still just shy of three, according to the US Census Bureau. This figure has actually changed little for more than five years, but the consensus seems to be that this may be changing soon. The advent of high-definition television (HDTV) programming, associated new form-factor sets (such as LCD TVs), and the impending mandated digital TV transition, are all expected to contribute to a boom in TV sales, and consequently to the number of sets in the average US household. The total number of TVs in a household is less important to a video service provider, however, than the number of TVs actually being used at any given time. Compounding that concern is the issue of what kind of content is being watched. Analysts estimate that nearly half of all TV households simultaneously use two or more TVs at least during part of the average day. Bandwidth-hungry HDTV content currently represents only a fraction of the total number of available channels today, but HDTV programming is growing apace and is universally expected to do so at an ever-increasing rate.

Digital video has been around for years. It is the linchpin of DBS services from the likes of DirecTV and Dish Network, since the limited bandwidth allocated for satellite transmission would otherwise support only a very limited amount of analog channels, and

signal quality can be more robustly maintained in the digital domain. Digital video use has expanded significantly in recent years in the Cable TV industry, as more and more specialized channels are added to operator’s lineups, and all-digital DBS has become a very real competitive threat. Key to the growth of digital video is the implementation of real-time signal compression and decompression. Current practice puts the bandwidth requirements of a single standard definition TV (SDTV) channel (or “stream”) at around 4 Mb/s, while HDTV demands between 14 and 19 Mb/s. As digital compression techniques improve, expectations are that SDTV requirements will reduce to perhaps 2 Mb/s, while HDTV may be viable at data rates as low as 8 Mb/s. Compression technique capabilities are summarized in the table below. Technology advances, moving away from MPEG-2 compression common in Cable and DBS to advanced compression schemes such as MPEG-4 and VC-1, represent one of the main enablers for the significant increase in interest around television over Internet Protocol (IPTV.) It is remarkable to observe that uncompressed digital HDTV signals require bandwidth on the order of 1.5 Gb/s, but compression technologies reduce this by nearly two orders of magnitude! Still, video compression and IPTV can’t combine to be the silver bullet for less-capable broadband architectures to enter into the triple play. Moreover, signals simply can’t be compressed indefinitely without some sacrifice in quality, and some recent studies have shown that average viewers do perceive differences in quality when even moderate increases in video compression are applied. Even at reduced data rates allowed by new compression techniques, HDTV still represents the obvious “killer app” of our time as it clearly requires always-on data rates higher than the total capacity of any standard high speed internet offering from either Cable or DSL.

	Current Requirements	Advanced Compression Techniques
SDTV	3 - 4 Mb/s	2 Mb/s
HDTV	14 - 19 Mb/s	8 - 16 Mb/s

Digital video compression current and future capabilities.

There are a variety of network architectures in use, and the ideal for network operators with existing infrastructures is to re-use what they have to the greatest extent possible. It is useful to review these legacy alternatives in comparison with FTTH, and evaluate the various video options that each can support.

The hybrid fiber coax (HFC) design deployed by Cable TV multiple system operators (MSOs) is the original “made for TV” architecture, as it was designed to support a large number of broadcast channels. Modern implementations of HFC can support total effective bandwidth of nearly 5 Gb/s, shared between 100 to 1000 subscribers. While the total bandwidth sounds very large, most of it is dedicated to supporting several hundred broadcast video channels, with the entire lineup transmitted to each and every subscriber.

The small percentage remaining is shared between on-demand services, Internet data, and voice traffic. RF video transmission is well suited to HFC networks, as it allows simultaneous broadcast of a wide variety of video services. RF transmission can support the large installed base of Cable-ready TVs with basic services without requiring additional set top electronics, or it can add premium options such as video on demand by incorporating a set top box. Since HFC network bandwidth is shared across a large number of subscribers, IPTV is not a clear fit, but the Cable TV industry continues to evaluate alternative options.

The various flavors of DSL cover a wide range of capabilities. Basic ADSL inarguably provides data rates too low to deliver a competitive video offering, even as compression techniques improve. Only recently have network operators begun to offer services greater than 1.5 Mb/s, with some areas seeing capabilities in the range of 3 Mb/s. It is worth mentioning that the total DSL bandwidth must be shared among all services, with some balance forced between data, voice, and video services if a triple play is attempted. Faster speeds are available where loop lengths are short and network infrastructure is in like-new condition. Still, considering the data rate requirements of current and even future digital compression techniques, the full capability of an ADSL line can be quickly exhausted by only a single video channel, and HDTV is practically out of the question. ADSL2+ and VDSL2 are now being considered as the paths for telcos to deliver video services over copper-based networks, by increasing data rates over much shorter copper loop lengths. Still, due to the significantly limited bandwidth capability relative to FTTH or even HFC, switched video solutions like IPTV are the only viable means of providing video over DSL by promising to deliver at most a few simultaneous channels to each user. This is one of the clearest distinctions between IPTV and RF transmission. In fact, some DSL providers have backed away from high end subscribers with 5 or more TVs due to the risk of not being able to support a worst-case scenario of multiple TVs each tuned to a different channel. Telcos hope that shortened copper loops and advanced compression will address this issue.

FTTH designs, especially passive optical network (PON) options, address the shortcomings of either HFC or DSL alternatives. The clearest advantage is the dramatically increased bandwidth capability. Fiber allows exponentially higher fundamental data rate capacity than DSL, while effectively eliminating the length-dependent limitations of copper. By exploiting wavelength division multiplexing (WDM), PONs can also incorporate the "RF overlay", replicating the full capability of an HFC system for video services on a dedicated wavelength while reserving separate wavelengths for upstream and downstream data and voice services. So, unique in comparison to the legacy broadband options, FTTH can efficiently support either RF video or IPTV. In fact, some have suggested that the true potential of FTTH might be realized by combining the two technologies. RF still provides the lowest cost video delivery option, especially considering the ability to support the installed base of TVs without a set-top box and to satisfy the widest variety of subscribers with multiple TVs, personal video recorders (PVR), etc. IPTV, on the other hand, holds great promise for interactive and on-demand services, broadening the scope of what TV can offer to

consumers, and enabling network operators to integrate voice, video, and data services onto a common platform.

Video signals are commonly considered to have the most demanding requirements of the triple play of services, whether transported in the RF or IP domain. While web pages can load slowly, email can be delayed, and phone call quality can be less than pristine, any degradation of TV signal quality will light up a network operator's switchboard faster than you can say "Heidi." RF transmission is subject to signal impairments that are well understood from years of experience in the Cable TV industry. RF analog signals must be carefully monitored to be within acceptable levels for parameters such as carrier to noise ratio (CNR) and composite second order distortion (CSO). In fact, minimum acceptable values for these are mandated by the FCC. RF digital signals are a bit more straightforward in being largely measured on bit error rate (BER), however these signals are fundamentally analog in nature and so BER is still driven by a number of analog behaviors. HFC networks must be carefully designed and monitored to maintain acceptable signal quality, particularly due to the noise and distortion contributions from coaxial cable signal leakage and RF amplifiers. FTTH networks, on the other hand, completely eliminate all but the short in-home coax connections. So, while RF signal impairments are still a source of concern, maintaining video signals almost entirely in fiber over FTTH automatically improves end of line transmission quality. IPTV fundamentally avoids the common RF impairments, but it has its own unique issues. IP fundamentally has its roots as a "best-effort" protocol, where packets might not make it to final destination on the first try in time, but they may eventually get there. Voice over Internet Protocol (VoIP) is one of the clearest examples of the change taking place in IP transport, as best effort just isn't good enough when dealing with real-time services like telephony. IPTV raises these issues to an even higher level, combining audio and video, and forced to meet the demands of the most discriminating couch potato. Packet loss, jitter, and latency, commonly monitored in IP networks, take on added significance when dealing with IPTV and introduce quality of service levels that can exceed even those seen in highly demanding enterprise applications.

Currently, FTTH deployments in the United States are divided between those deploying video services over RF and those opting for IPTV. A recent poll by the United States Telecom Association showed that network operators planning FTTH deployments are split nearly 50/50 in their choice of one video alternative over the other. As the biggest players begin to roll out their deployments, the landscape will change. Clearly, the implications will go beyond just FTTH, as any success by telcos will surely drive some response from Cable and DBS.