1 Evolving Viewing Paradigms

1.1 OVERVIEW OF THE EVOLVING ENVIRONMENT

Many industry observers share the view that "*The television sector is facing a challenging and an unprecedented period of transformation… Television [is] at Crossroads*."[1] A number of forces are expected to reshape the video distribution and consumption environments during this decade. Major drivers for this evolution include (1) new viewing habits, such as time shifting for nonlinear and on-demand content consumption, (2) new distribution channels (effectively, new content providers, especially Internet-based, along with new transport mechanism, such as streaming), (3) new technologies, and, (4) standardization of Internet Protocol (IP)-based delivery, especially in conjunction multicast-based IP Television (IPTV) networks and/or with web-based content downloading (streaming) and social networks.

New viewer paradigms are evolving related to consumption of entertainment video and TV programming that can be summarized as "anywhere, anything, anytime, any platform"; namely, "from any source, any content, in any (encoded) form, at any time, on any user-chosen device, consumed at any location." Many new TV sets that now have Ethernet networking connections built directly into the set and require no additional equipment or set-top boxes (STBs) for directly accessing the Internet; also, many high-end TVs already come with the ability to conduct video calls. In the view of some industry observers, these viewer habits, technologies, and approaches will play a part in eventually supplanting broadcast and cable television with Internet programming and distribution. While these predictions may not come to such a full dénouement in the immediate short or medium term, say, mid-decade, it is worth, nonetheless, to consider what the potential implications are for all stakeholders for the end-of-the-decade and beyond.

In this work, we refer to this new paradigm as Nontraditional TV (NTTV). New viewer approaches include, but are not limited to the following:

[1]Speakers at the Future TV 2009 trade show, Paris, November 9 and 10, 2009.

Linear and Nonlinear Video and TV Applications: Using IPv6 and IPv6 Multicast, First Edition. Daniel Minoli.

- Watching entertainment/news using the Internet (such as a TV show, a movie, or a short clip).
- Watching a multicast (rather than broadcast) entertainment/news program.
- Watching a video on-demand (VoD) program (such as a movie or pay-per-view event; VoD is also known as content on-demand [CoD]).
- Watching time-shifted TV (TSTV):
  - utilizing home-based hardware; or
  - utilizing network-based hardware.
- Watching entertainment/news with a mobile smartphone, a PDA (personal digital assistant), a videogame console (e.g., the Microsoft Xbox 360 and Sony PlayStation 3), a tablet screen (e.g., Amazon Kindle Fire/Apple iPad/B&N Nook), or a device in a car or boat.
- Watching user-generated content (UGC), particularly utilizing social networks.

In this work, time shifted implies the capture of (what was) a live-TV program, either by a customer device or a user-programmable network-resident device, for playback within a relatively short time (up to a few days). Time shifting does not include, in our definition, VoD downloads of a commercially packaged video clip from a Cable TV provider or from an Internet site. Some other related definitions are in order as follows:

- *Internet television* (also known as Internet TV, online TV) is a television service distributed via the Internet by streaming, as exemplified by services such as Hulu (for U.S. content) and BBC iPlayer (for U.K content). The content is typically commercially produced TV material, but the "transmission/distribution" channel is the Internet; the "transmission/distribution" also includes network-resident storage (supported by video servers). Internet TV content is delivered over the open Internet as the term implies (not over a dedicated IP network). Content providers can reach consumers directly, regardless of the carrier or carriers providing the Internet backbone connectivity or Internet access. Video content is accessible from any Internet-ready computer device and is accessible around the world—a consumer does use STBs, although increasingly TV sets and STBs have direct Internet connections themselves. Video content is now increasingly available on the Internet. In the past, Internet TV has suffered from low quality; this limitation is now being progressively overcome due to greater bandwidth availability in the Internet core and in the consumer's access. Some approaches also use peer-to-peer (P2P) protocols.
- *Web television* (Web TV, also known as web video) is a genre of digital entertainment distinct from traditional television: in Web TV, the content is created specifically for first viewing on the Internet (via broadband access and/or on mobile networks.) Web television shows, or Web series,

are original episodic shorts (2–9 minutes per episode at press time, although longer episodes may appear in the future). Some notable series include *Dr. Horrible's Sing-Along Blog*, *The Guild*, and *Prom Queen*. Web television networks included the following at press time (however, some of these also post TV-originated material): The WB.com,[2] MySpace, YouTube, Blip.tv, and Crackle.

- *Time-shifted TV* is a service or capability that allows the consumer to watch a TV program originally as a broadcast-, cable-, satellite-, or IPTV-transmission, that has been time shifted. The time shift service has two flavors. In a basic flavor, the user can preplan the recording of a scheduled TV program (using a local user-owned device, a local cable-provided device, or a remote network-based device); the user can watch the program any time later while still being able to pause, rewind, and resume the playout. Some systems allow the user to skip commercial advertisements during playback. In a more advanced flavor, the service allows a user to halt a scheduled content service in real time and allows the user to continue watching the program later, by providing buffering for pause, rewind, and resume functions. Some refer to time-shifted TV as "catch-up TV," being that it allows consumers to watch a broadcaster's program at their own convenience.
- *IPTV* is a framework and architecture that when instantiated in an actual network supports efficient distribution of (targeted) multimedia services, such as television/video/audio/text/graphics/data. The content is delivered over IP-based networks (these being IP Version 4 (IPv4) based and/or IP Version 6 (IPv6) based, instead of being traditional cable-based) that are tightly managed to support the required level of quality of service/quality of experience (QoS/QoE), security, interactivity, and reliability. Its services are provided to customers via a subscription mechanism very similar to traditional Cable TV service.

Collectively, we refer to the first two approaches listed above as Internet-Based TV (IBTV). See Table 1.1 for related concepts (table compiled from various industry sources). Internet-based devices that support IBTV viewing are becoming more popular, ranging from hybrid Internet-ready STBs and digital video recorders (DVRs), to home theater PCs (HTPCs) (that obviously are Internet-ready), to Internet-ready TV sets. These devices enable the kind of transition that is discussed in this text. An HTPC is a converged device that combines a personal computer with a software application that supports video playback; the HTPC unit is typically colocated with a home entertainment system.

[2]Companies named in this text are simply illustrative examples of entities that may offer technologies and services under discussion at a point in the text; named companies are generally not the only suppliers that may provide such services, and mention of a company and/or service does not imply that such entities or capabilities are recommended herewith or considered in any way better than others.

TABLE 1.1 Various Evolving TV Technologies, Services, and Approaches (Partial List)

Technology/Service	Description
Broadcast TV	One-way transmission of TV signals from one point to two or more other points.
Connected TV	TV sets with built-in Ethernet/WiFi/Internet capabilities.
Converged services	The integration of Internet, multimedia, e-mail, presence, instant messaging, mobile commerce (m-commerce), and/or services with voice service.
Internet-based TV (IBTV)	Video distribution approaches such as Web television, Internet television, and/or User-Generated Video (UGV).
Internet Protocol (IP) TV (IPTV)	Multimedia services, such as television/video/audio/text/graphics/data, delivered over IP-based networks that are tightly managed to support the required level of Quality of Service/Quality of Experience (QoS/QoE), security, interactivity, and reliability. Access is usually provided via a subscription service very similar to traditional Cable TV service, except for the transport network, that is IP-based (IPv4 and/or IPv6). Content is supplied to a set-top box to be watched on a TV set. IPTV is a method of delivering video using an IP network (as an alternative to cable or satellite, but increasingly in conjunction to these systems). IPTV utilizes a closed, tightly-managed network (a "walled garden"), operated by a telecom provider, often as part of a "triple-play" bundled package (TV, Internet, and voice) [SJO200801].
Internet television (also known as Internet TV, and/or Online TV)	A television service distributed via the Internet, as exemplified by services such as Hulu (for U.S. content) and BBC iPlayer (for U.K content). The content is typically commercially produced TV material, but the "transmission/distribution" channel is the Internet; the transmission/distribution' also includes network-resident storage (supported by video servers).
Linear TV	A television service in which a continuous stream flows in real time from the service provider to the terminal device and where the user cannot control the temporal order in which contents are viewed. Typically found in Broadcast TV environments.
Nontraditional TV (NTTV)	New viewer approaches include (but not limited to) the following: watching entertainment/news using the Internet (such as a TV show, a movie, or a short clip); watching a multicast (rather than broadcast) entertainment/news program; watching a Video On Demand (VoD) program (such as a movie or pay-per-view event); watching time-shifted TV (TSTV); watching entertainment/news with a mobile smartphone, a PDA (personal digital assistant), a videogame console, a tablet, or a device in a car or boat; and/or watching user-generated content, particularly utilizing social networks.
Over-The-Top (OTT) streaming devices	(Also known as OTT set-tops) devices employed by viewers to watch shows or programs via multimedia and open public networks (particularly, the Internet). OTTs enable smart TVs, set-top boxes, PCs, tablets, smart phones, and game consoles to receive and process streaming video. Newer TV sets may have this functionality built in.
Package	A collection of content components that in some combination (either all or a subset) together provide an end-user experience and are intended to be used together.

TABLE 1.1 (*Continued*)

Technology/Service	Description
Pay Per View (PPV)	A TV service where a particular program event (e.g., a yachting race) can be bought separately from any package or subscription. The transmission of the program event is made at the same time to everyone who has ordered it.
Personal mobility	Capability to support mobility for those scenarios where the end-user changes the terminal device used for network access at different locations. The ability of a user to access telecommunication services (including video content) at any terminal on the basis of a personal identifier, and the capability of the network to provide those services delineated in the user's service profile.
Retransmission broadcast service	A service in which content is provided from various broadcasting environments, including, but not limited to, terrestrial, satellite, and cable, and retransmitted into IP network simultaneously or otherwise.
Time shifting	A function that allows playback of content after its initial transmission.
Time-shift TV (TSTV)	A service or capability that allows the consumer to watch a TV program that has been time shifted. The time shift service has two flavors. In a basic flavor, the user can preplan the recording of a scheduled TV program (using a local user-owned device, a local cable-provided device, or a remote network-based device); the user can watch the program any time later, while still being able to pause, rewind, and resume the playout. In a more advanced flavor, the service allows a user to halt a scheduled content service in real time and allows the user to continue watching the program later, by providing buffering for pause, rewind, and resume functions. There may also be advanced playout controls, for example, skipping to chapters, bookmarks, jump to time, and so on [OIP200801].
Trick mode functionality	The ability to pause, rewind, or forward stored content. A TV with trick mode is a TV service with trick mode functionality.
User-generated video (UGV)	Video content created by the user community and distributed over the web with social networks, YouTube, and so on.
VoD	(Also known as Content On-Demand—CoD) A service in which the subscriber can view commercially-produced video content whenever desired. The operating assumption is that the content is stored on the provider's VoD server. The subscriber accesses the movie from a library directory; the interface may include a search engine that accesses the movie description and rating. Subscribers typically have the ability to pause, play, rewind, fast forward the content, or even stop viewing it and return to it at a later time.
VoD trick modes	Download and streaming VoD systems provide the user with a large subset of content display control functionality, including pause, fast forward, fast rewind, slow forward, slow rewind, jump to previous/future frame, and so on. These functions are usually referred to as "trick modes."
Web television (also known as web video)	A genre of digital entertainment where the content is created specifically for first-viewing on the Internet (via broadband access and/or on mobile networks.) Web television shows, or Web series, are original episodic shorts (2–9 minutes per episode), but which may become full-fledged 30–60 minute clips in the future.

On the other hand, new Internet-ready TV sets bypass the PC altogether and access the Internet directly; these sets support the concept of "connected TV (CTV)" [FUT201101]; CTVs are also known in some circles as "Smart TVs." About 25% of flat panels sold in 2011 had WiFi/Internet capabilities, and about 50% of total flat-panel televisions shipped in 2015 (about 140 million units) was expected to have Internet connectivity. By the end of 2015, more than 500 million Internet-connected TVs will be in homes. TV manufacturers are (apparently) "betting" on the expansion of direct-to-consumer offerings from content producers and outfits such as, but not limited to, Netflix®. It should be noted that the adoption of CTV is not just taking place in developed regions, but also in emerging markets that have good broadband services [MEL20101]. Netflix, Amazon, and Apple are (reportedly) "banking" on the idea that the Internet in general, and cloud computing services in particular, are going to be a game changer for home entertainment, and that the TV screen can be seen as a "big iPad."[3] As an illustrative example of evolving approaches, it was announced recently that Caros Slim, a noted Mexican entrepreneur, is reportedly financing an Internet TV network, Ora.TV, that is expected to include an interview show with Larry King; Ora.TV will feature on-demand content and will produce a set of programs that, by design, will transcend traditional formats.

Table 1.2 depicts the TV population in North America in 2010; some observations about global trends are also included.

A line of investigation such as discussed in this text:

> . . . is justified because the depth of change to the fundamental approaches being taken to providing multimedia telecommunications services … [ITU200901].

Traditional linear TV has been around for a long time. Linear TV is a television service in which a continuous video stream flows in real time from the service provider to the terminal device and where the user cannot control the temporal order in which contents are viewed [ITU200801]. DVRs enable the process of TV time shifting; equipment of interest includes the personal video recorder (PVR) and the network personal video recorder (nPVR) (this last device also known as remote storage DVR [RS-DVR]). An nPVR is an end user-controlled device that records, stores, and plays back multimedia content (a PVR is also known as personal digital recorder [PDR]). An nPVR supports the same functionality as a PVR except that the recording device is located at the service provider's edge node (e.g., in the STB), or in the provider's network.

Approximately 30% of the TV viewing population was making use of time shifting at press time, although the number of hours per month watching such

[3]The examples of commercial services and service providers identified at various points throughout this text are intended only to depict what we believe to be persistent technical/usage trends. Some of these service, providers, or products may disappear—yet other will emerge. Hence, we believe that the general trends discussed here, as a whole, will persist and prevail.

TABLE 1.2 TV Customer Profile in North America (2010)

Category	North America Population	Subpopulation	Notes	Prospects
Total households with TVs	116 M			Stable
Cable households		60 M (52%)	Comcast, cablevision, Time Warner, Cox, Charter cover 80% of market	Stable in North America. ROW: no major anticipated growth next few years
DTH households		34 M (29%)	Dish Network and Direct TV	Stable in North America. ROW: no major anticipated growth next few years
Fiber/IPTV/telco households		7 M (6%)	AT&T U-verse and Verizon FiOS	Stable in North America. ROW: some growth next few years
Terrestrial		15 M (13%)		Stable in North America. ROW: some growth next few years
Broadband only				Worldwide growth next few years

programming was still relatively small. However, these trends are expected to continue to progress until a certain quiescent point is reached. As of press time, according to Nielsen, in the United States, people spent approximately 159 hours a month consuming entertainment and news from TV and Internet sources; about 15 hours were on NTTV (10 hours : 46 minutes for TSTV and 4 hours : 43 minutes on Internet sources).[4] Real-time linear broadcast will likely never go away in total because people also want to (continue) to enjoy a disengaged noninteractive experience, but the amount of NTTV time will definitely increase in the future. Nielsen research (see Appendix 1A) shows that between 2008 and 2011, the amount of time spend on TSTV has been growing at a compound annual growth rate (CAGR) of 20–30% a year and the amount of time spend on Internet-delivered content has had a CAGR of 30–40% a year. Some describe "*TV viewers' stampede to online as a 'wildfire'*," and observers articulate the fact that the cable TV industry "*is feeling the pressure*" [LOW200901].

If one accepted that certain assumptions about the growth rates of NSTV habits continue to hold, by 2017, the traditional TV viewing time will decrease from 145 hours in 2009 to 125 hours in 2017, while NTTV will grow to 57 hours (22 on TSTV and 35 on Internet sources). See Figure 1.1 for a graphical view of these trends; Appendix 1A provides some primary data and projections.

In addition, a lot of content is now available online, both in the stored form (e.g., YouTube, Reuters, CNN, Hulu, and Netflix), as well as real time (e.g.,

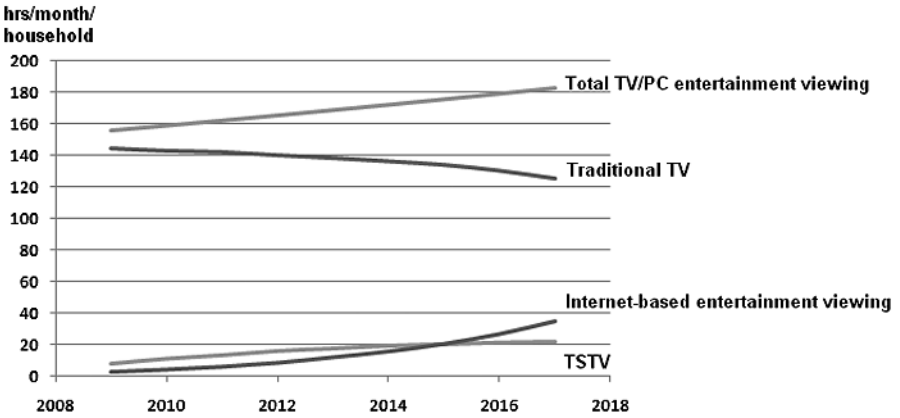

FIGURE 1.1 Apparent transition in viewing habits over time (estimated based on assumptions).

[4]Nielsen data covers the total population in the U.S. over age 2, namely 297 million Americans. Note that that this equates to about 47.3 billion hours per month in the U.S. spent on home-based video entertainment, or 557 billion hours a year.

MSNBC, CNN International, France 24, and BBC World News). Astonishingly, the website wwiTV.com listed (and linked to) over 2250 TV streaming sites at press time from 143 counties around the world—visiting the site is quite an experience. An estimated 11% of U.S. consumers ages 13–31 view streamed or downloaded video via a console at least once a month [FUT201101]. Observations such as this one may be worth pondering:

> . . . Incumbent cable and satellite pay-TV operators face increasing competition from both IPTV operators, such as Verizon FiOS, and all the other new entrants into the market. Their greatest fear is "cord-cutting"—that subscribers will cancel their subscriptions because video via connected TV is a good enough and often cheaper alternative. One response in the USA is the TV Everywhere initiative. This aims to provide an improved service to subscribers by offering television and VoD via the whole range of viewing devices: not only TV, but also PC, smartphone and iPad . . . Internet connectivity fundamentally changes the nature of television by giving viewers access to video-on-demand, Web video and new online services, such as social networking. The last of these, using Facebook and Twitter with TV, has radical implications for the future of television viewing and the business of TV . . . [FUT201101].

The long-term outlook for DVDs and Blu-ray discs is questionable. Industry observers have noted that there are few bright spots in the DVD retail environment: the TV series box set; however, according to these observers, streamed-TV usage is growing, and it is no longer a service dominated by movies: 50–60% of streamed viewing is now for TV episodes [THO201101]. Along those lines, the following observations are important to the concepts addressed in this text:

> Countries with more than 60 percent home broadband penetration include the majority of Western Europe, the USA and Canada, Australia and New Zealand. In Asian countries, such as Japan, South Korea and Singapore, penetration is 100 percent. Through broadband, many consumers are already viewing Internet video at home via PCs, laptops and smartphones. Many watch TV and simultaneously use Internet services, such as social networking. The time has now come for the television set too to go online and bring home audiences increased video choice, combined with new interactive services. Consumer electronics manufacturers, game console firms, tech companies and pay-TV operators are competing to connect home TV sets to the Internet. Each has powerful commercial imperatives for doing so [FUT201101].
>
> The biggest threat to revenue growth [for traditional providers] will be online (or "over-the-top") viewing, which allows users to stream programming delivered over the Internet via sites like Hulu and YouTube, and to aggregate programming via services such as Boxee [HEY201001].

Many U.S. TV networks and broadcasters (among others) now have their own websites that provide sponsored content. The Internet is being touted as the "future of home entertainment." Press time observations describing the environment include ones such as this [AXO200901]:

> Web television has matured significantly in 2009; we've seen the introduction of the "Streamy Awards[5]" . . . and the launch of more internet TV-related startups than we can count. TV-over-IP (IPTV) is starting to hit television sets thanks to set-top-boxes, TVs, and disc players with built-in streaming capabilities, and like print media before it, traditional broadcast television is beginning to grapple with the inevitability of an Internet-driven future …

Other changes include, but are not limited to the following [SVE201101]:

> . . . In the future, believing that the TV is talking to you might not be a sign of insanity. You may be getting a Skype video call. Comcast Corp . . . plans to bring Skype calls to TV sets later this year [2011]. Subscribers will then be able to rent a kit from Comcast that includes a webcam and an adapter that plugs into the TV. A new cable box remote will include a keyboard on the back, for typing chat messages . . .

A political campaign consultant states that advertisement campaign expenditures may now be equally allocated to online ads as to TV ads [AVL201101]:

> The rules of the game are shifting because convergence is finally occurring. "It matters less and less every year what screen you watch ads on . . . I'm just as likely to watch CNN on an iPad as a TV screen."

Related to Web TV, at press time, YouTube announced the creation of 100 new online YouTube channels with original programming. The company reportedly spent months working with Hollywood agencies and has secured deals with a number of celebrities. Most of these channels were expected to launch in 2012, creating about 25 hours of new programming per day. The company will reportedly share ad revenue with the content creators, giving 55% of revenue to the content creators, who it calls "partners," keeping 45% for itself. The goal is to make available professionally generated content created just for the web, just for the YouTube platform. These new channels are valuable because they are not just limited to users' laptops. With the rise of Internet-connected TVs, with interfaces such as Google TV, consumers will be able to seamlessly watch this content on their flatscreens [BOO201101].

A number of major providers make available digital (video) content for purchase over the Internet, including, among others, Apple's iTunes Store, Amazon, Netflix, and Wal-Mart; this is in addition to sites that have free (but legal) content. Observers note that consumers are finding appealing entertainment and information choices on the Internet—and have already set up data networks for their PCs and laptops that can also help move that content to their TV sets. Internet-ready TVs go a step further. For example, Netflix Inc. announced a deal with Korea's LG Electronics Inc. to make a Netflix online-video service available on a new line of high-definition TV sets from LG; the online service offers 12,000 movie and television titles [WIN200901]. Netflix had over 24 million subscribers in the United States and Canada at

[5]The International Academy of Web Television was founded in 2008 with the charter to organize and support the community of web television creators, actors, and producers. It sponsors the Streamy Awards.

press time for its online streaming service; its ability to stream Disney, Sony, and Starz movies aided its growth in recent years.[6] Other providers are also entering the video streaming market. For example, Wal-Mart Stores Inc., the world's largest retailer, recently located its Vudu video streaming and rental service on the Walmart.com website to optimize exposure and consumer access. Vudu (a Wal-Mart division) streams films and shows to computers, certain televisions, Blu-ray DVD players, and Sony Corp's Playstation 3 [WOH201101]. Apple's iTunes Store is an online digital media store that supports digital content distribution (see Figure 1.2 for a snapshot of the storefront). The Store (site) started its service in 2003. It reportedly has over a quarter-of-a-million digital items for download, including music, TV shows, movies, podcasts, and audio books. Cloud technology is now used for content management. Around press time, Apple announced that Digital Rights Management (DRM) had been removed from 80% of the entire music catalog in the United States; however, television shows and movies are still protected under the DRM (Apple's DRM system is called FairPlay.)

While time shifting is catching on, some note that there are even more dramatic viewing habit shifts among the young. Specifically, the tendency for the young to not be happy to watch a single video stream at once, and, instead create mash-up desktops of video, audio, text messaging, and social media, all at the same time. Others may also want to watch a video mosaic, say of 2×2, 2×3, 3×4, or other combination of video windows on a single (large) or multiple (wall) screens.

Although current generation of Internet-based services may in some instances (still) imply the use of small screens and the "buffering" latency phenomenon, these issues are basically driven by bandwidth availability along various portion of the Internet path or the video server; this predicament is like to improve over time, with the increasing deployment of high-capacity fiber in the (Internet) backbone and in the access network. Dense wavelength division multiplexing (DWDM) technology is propelling this transition forward. Customer connections in the 10–16 Mbps now available in many parts of the United States (and other developed parts of the world) should prove reasonably adequate as a starting point for the services envisioned;

[6]It should be noted, however, that in 2011, Netflix raised its prices for DVD delivery by mail, apparently because the company miscalculated how many people still want to receive DVDs by mail each month, a more expensive service to provide compared with its streamed Internet videos. According to observers, Netflix has been trying to lure subscribers away from its DVDs by offering cheaper plans that include movies and TV episodes delivered over its Internet streaming service. In 2010, the company began offering a streaming-only plan for $8; yet Netflix customers were not flocking to Internet video as quickly as some analysts said the company expected. DVDs feature newer titles and the latest theatrical releases that are not available through the company's streaming service. Under the new plan, customers who want to rent DVDs by mail and watch video on the Internet will need to pay at least $16 per month. The price hike serves multiple purposes: it may likely push more people into the streaming service, which in turn will help the firm lower its postal expenses. The company states that its future is not in the DVDs; its future is in the business of premium pay television delivered over the Internet [CUT201101]. Other pricing arrangements may be announced and/or tried in the future.

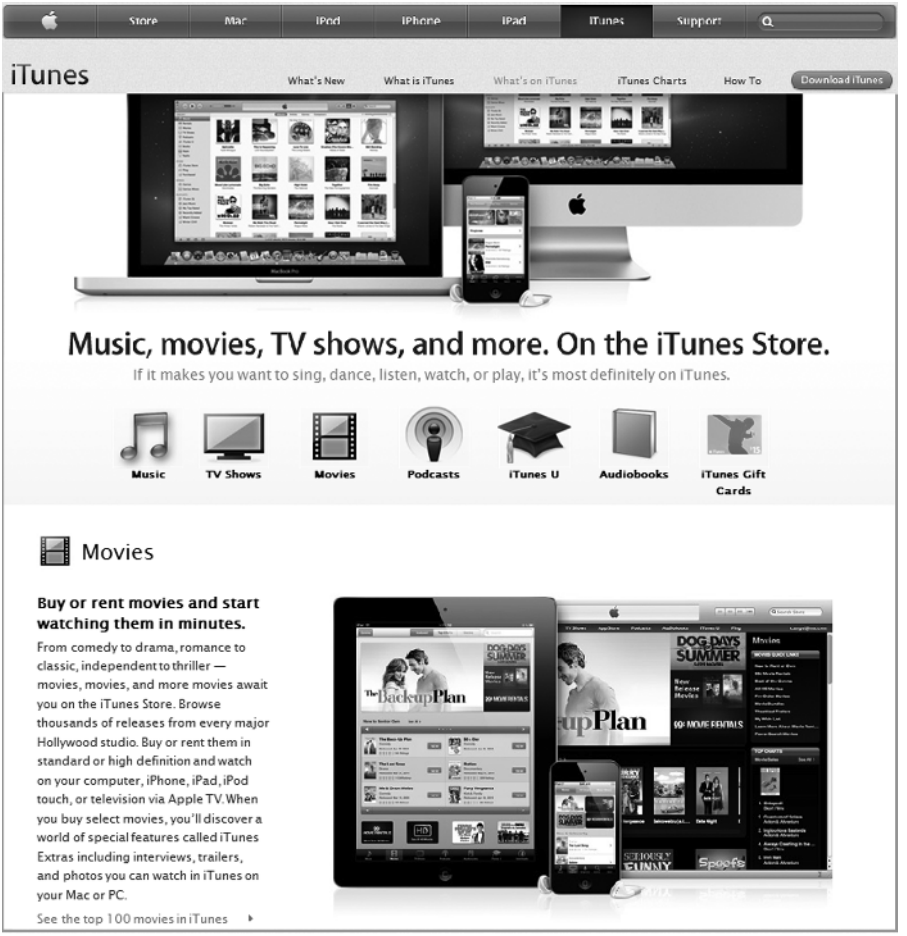

FIGURE 1.2 A snapshot of the Apple's iTunes Store storefront.

access rates of 100 Mbps, and even 1 Gbps may be available to some consumers by 2012–2013. Watching a streaming movie requiring 0.5–2.5 Mbps flow (depending on video quality) over a 16 Mbps Internet connection is not such a technical feat at this point in time (however, performance also depends on the remote server); high definition TV (HDTV) flows require around 5 Mbps.

Video rental methods are discussed next. Internet video-on-demand (iVoD) is a class of transactional digital rental methods that includes electronic sell-thru (EST) and download-to-own (DTO), but when such rental is downloaded via the Internet (rather than being done over a Cable TV network or an IPTV network). See Table 1.3 for a definition of terms. The transactional online movie market is rapidly outstripping the traditional DVD retail market. Observers called 2010 a watershed year in many respects for transactional online movies internationally; they saw it as a year characterized by the

TABLE 1.3 Transactional Digital Rental Methods

Internet Video On Demand (iVoD)	(Some also call this Interactive VoD) Transactional digital rental methods, specifically when such rental is downloaded via the Internet (rather that being done over a Cable TV network or an IPTV network.) *Note*: The term has not totally congealed in the industry. Some define iVoD as a capability that enhances traditional VoD services by providing trick modes; others define iVoD is as a system that uses a consumer's home broadband connection to deliver video content directly to the TV set.
Electronic sell-thru (EST)	(Also known as Digital Retail) A method of media distribution where consumers pay a one-time fee to download a digital media file for storage on a hard drive on a computer or other system. Typically the content may become unusable after a certain period and may not be viewable using competing platforms. EST covers a gamut of digital media products, including TV content, video content, music, gaming, and mobile applications. The delivery mechanism may be the Internet or other networks (e.g., Cable TV network or an IPTV network, or a 4G wireless network.) *Note*: Some exclude delivery over the Internet in the definition of EST; we include it.
Download-to-own (DTO)	A method similar to electronic sell-thru (EST) but where the consumer may permanently own and/or be able to use the content. Some observers suggest that the increasing popularity of VoD *rental services* can be linked to the gradual erosion of support for download-to-own (DTO), or digital retail business. It believes that the majority of services operating in global markets offer titles on a rental basis due to limited availability of download-to-own titles whose fundamental business model offers no compelling case in terms of convenience or service to drive a mass-market adoption [OHA201101]. The delivery mechanism may be the Internet or other networks (e.g., Cable TV network or an IPTV network, or a 4G wireless network.) *Note*: Some exclude delivery over the Internet in the definition of DTO; we include it.

continued expansion of key services,[7] especially outside of the United States, tapping pent-up early adopter demand for online movies (by way of contrast, analysts predict that that annual store-based rental revenue will continue their almost inexorable decline) [OHA201102]. iVoD (VoD rental services with film and/or video downloaded using the Internet) is expected to grow rapidly with the increasing penetration of broadband and newer computers and/or CTVs

[7]Market research showed a 93% year on year rise in total online movie revenues in 2010 for markets outside of the United States to $243 million. The top five international countries in terms of market size—the United Kingdom, South Korea, Germany, France, and Canada—accounted for just over three quarters of total revenues. Driving growth was a combination of the continued

with larger hard drives.[8] Until recently, the limited playback options of movie downloads, low quality, and the effort of getting movies transferred from the desktop PC to watch them on flat panel TV screens has made movie downloads somewhat impractical for home theatre use; but the situation is changing driven by the mass availability of new Internet-ready CTVs, STBs, and services from firms such as Apple, Netflix, Amazon, Microsoft, Rovi, Sony Computer Entertainment and Wal-Mart [OHA201101].

As noted, IPTV is the well-developed formal framework and architecture for the delivery of (entertainment-quality) video programming over an IP-based network. This technology is expected to be used to deliver somewhat traditional TV services, but the technology can also be used for NTTV and for TSTV in particular. Telecom carriers are looking to compete with Cable TV companies by deploying IP video services, such as IPTV, over their networks. IPTV provides all the advantages of traditional "linear" TV in terms of service quality, combined with the many advantages the Internet offers in terms of choice and interactivity; but it should not be confused with web streaming, because images are not delivered over the Internet, but rather to homes through a "managed network." This means TV programs do not have to compete with other traffic on the public Internet, which could negatively impact the viewing experience [ITU201001]. IPTV is a step along the transition continuum discussed in this text; other technologies and approaches are also explored.

1.2 NEW CONTENT SOURCES AND SINKS

The viewing changes discussed above, even if the projected migration to NTTV turns out to be less severe than noted in the previous paragraphs, are expected to have considerable impacts on the infrastructure utilized by providers to deliver content, for the infrastructure ranging from broadcast TV, to IP-based networks operating over fiber, to satellite delivery, to 3G/4G wireless networks, and to server-based on-demand content distribution systems.

Figure 1.3 depicts the evolving "from anywhere to anywhere, anytime" home entertainment-consumption environment that is the subject of this text. Content providers and subtending distribution channels include the following:

rollout of Apple's iTunes, which launched in six new markets, and the first full year of operation in some regions of not only iTunes but also Microsoft's Zune Video Marketplace and the Sony PlayStation Network. The market research firm IHS Screen Digest predicted that by 2015, the overall the business of online movies will generate $786 million, with just over half (54.3%) through traditional VoD and 45.7% from the rapidly growing Internet-based VoD [OHA201102].

[8]A press time report by Global Industry Analysts (GIA) predicted that by 2017, the global World Online Movies market will be worth $4.44 billion [OHA201101]; others predict a market of $1 billion in 2015 (excluding North America) [OHA201102].

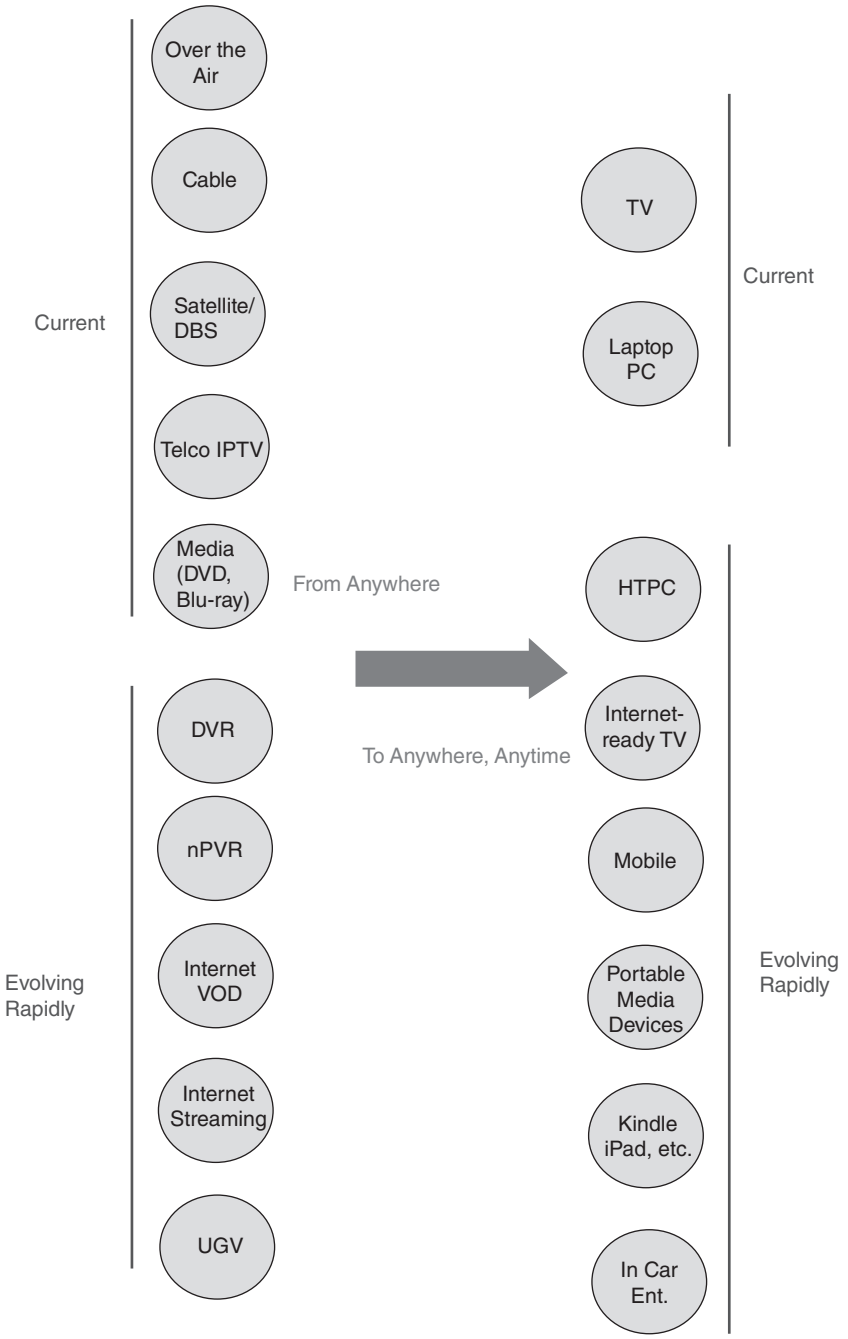

FIGURE 1.3 The evolving "from anywhere to anywhere, anytime" environment.

Traditional Content Providers/Transporters

- Over-the-air broadcasters
- Cable TV providers, also providing VoD
- Satellite backbone providers, satellite direct broadcast (DBS) providers (this also known as direct-to-home [DTH]) with satellites operation in the geosynchronous orbit
- Telecommunications carriers offering IPTV services
- Stored media sources (digital video disc [DVD] and Blu-ray Disc [BD])

Rapidly Evolving Content Providers

- DVR (consumer owned), such as TiVo-based services
- Network-based DVR, also known as nPVR—which can be seen as a form of Cloud Computing, but for video applications
- Internet-based VoD
- Internet-based streaming (real time, downloadable/commercial, network-resident such as YouTube, Hulu, and social networks, among other services. This includes all forms of IBTV.). This approach may use over-the-top (OTT) streaming devices (also known as OTT set-tops).
- User-generated video (UGV) (also called UGC)

Display devices include the following:

Traditional Display Devices (Screens)

- TV screens
- PCs and laptops

Rapidly Evolving Display Devices (Screens)

- Internet-ready TVs (also known as Connected TV)
- HTPCs
- Portable media devices, such as Kindle/iPad-like tablet devices
- Video game consoles
- Smartphones
- In-car entertainment devices

Industry observers note that data and media are being untethered from specific devices or networks. Advanced mobile devices deliver a combination of functions previously available only from multiple tools [NIE201001]. To illustrate the availability of new devices, note that in 2011 Microsoft announced that owners of the Xbox 360 gaming console would be able to start watch TV shows and other content through their gaming consoles, although most of that will not be free; content was expected to be available in more than 20 countries

[ORT201101]. Microsoft has sold 55 million Xbox 360 consoles worldwide since they were introduced in 2005. Microsoft was partnering with services, including Bravo, Comcast, HBO GO, Verizon FiOS, and Syfy in the United States, BBC in the United Kingdom, Telefónica in Spain, Rogers On Demand in Canada, Televisa in Mexico, ZDF in Germany, and MediaSet in Italy, to bring on-demand and live television content to the Xbox. Consumers will still need is a subscription to Comcast or other pay TV services; additionally, some live TV channels were expected to be available. The Xbox does not replace the STBs currently used to access TV programming, but it can be used for households where members want to able to access TV content in different rooms of the house without having to use a second STB.

Figure 1.4 illustrates the traditional TV/entertainment video distribution environment that was in place in the 2005–2010 timeframe (also accompanied by a transition from analog distribution to digital distribution for the over-the-air and cable TV sources). Each of the lines in this diagram represents detailed technical interface specifications that have evolved over the years, specific to each interface.

Figure 1.5 depicts new consumer devices that are being used to capture and display traditional TV/entertainment video. Again, each of the lines in this diagram represents detailed technical interface specifications that have evolved recently or are now emerging, specific to each interface. It should be noted that the larger content-consumption pool can actually be beneficial to the current (traditional) content providers. We mentioned earlier the HTPC; the HTPC software interface incorporates a user interface design (video scalar capability) allowing the video to comfortably viewed at typical TV viewing distances. Commercially available HTPCs almost invariably support a "TV-out option" using a HDMI, DVI, DisplayPort, component video, VGA (for some LCD televisions), S-Video, or composite video output. A remote control device is typically supported; keyboards are also often included. Some models include DVR functionality. A HTPC can be purchased with the requisite hardware and software needed to add television programming to the PC, or can be assembled from discrete components (e.g. with software based HTPC setups). Internet-ready CTV sets offer other novel opportunities and may be more likely to succeed in the market than HTPCs. The sheer quantity of interfaces and sinks should reinforce the technical and business opportunities for providers and technology developers.

Figure 1.6 shows some new sources of video content for traditional viewing devices, along with the implicit technical interfaces required to support these sources. These sources can represent a threat to both the distribution networks of the traditional content providers, as well as to the advertisers that (ultimately) support content creation. There is also a trend related to UGV. These sources support NTTV paradigms in general and TSTV in particular. There is a large global infrastructure in support of the traditional TV contentment distribution model, and these "new" sources are likely to drive a rearchitecting of this infrastructure during the course of this decade. This figure illustrates

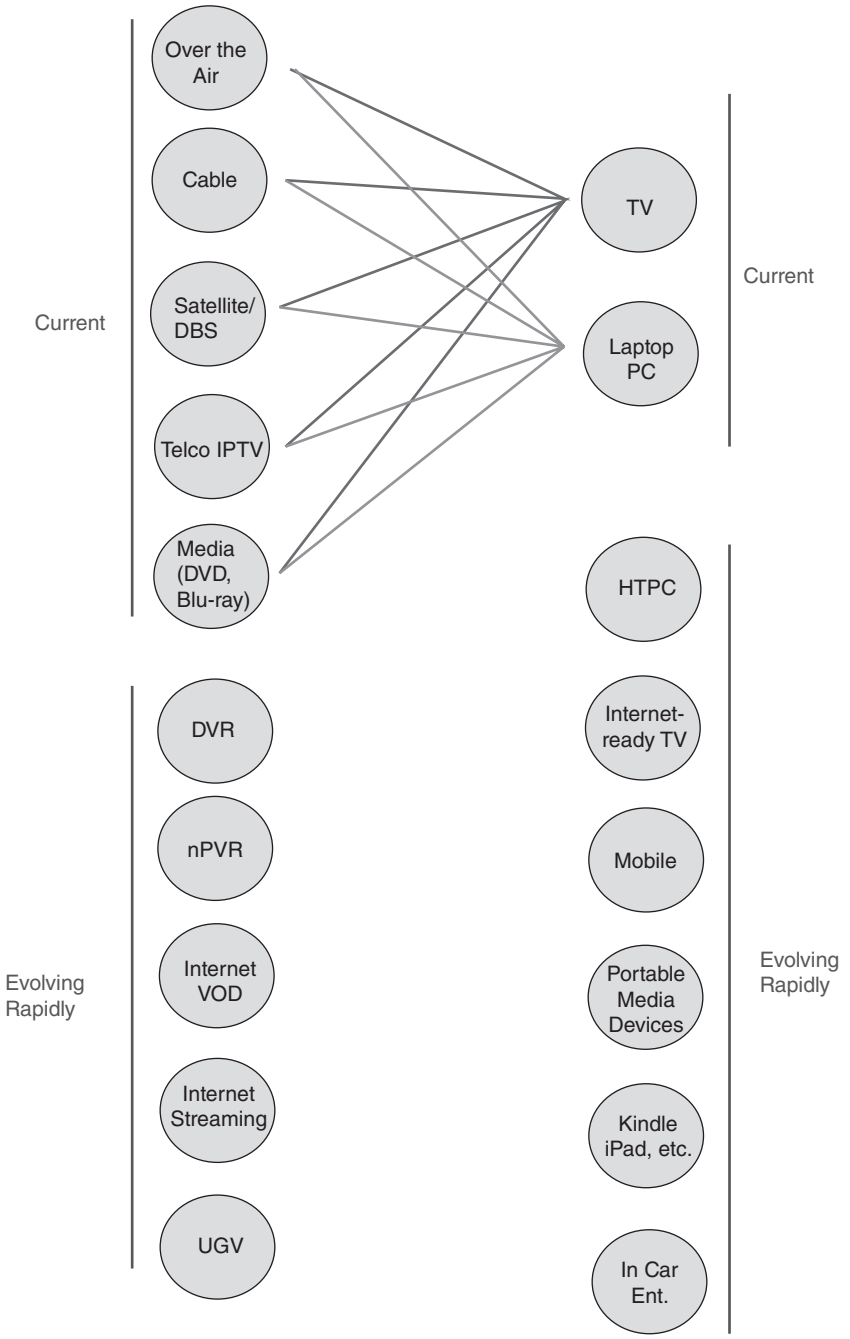

FIGURE 1.4 Traditional TV/entertainment video distribution.

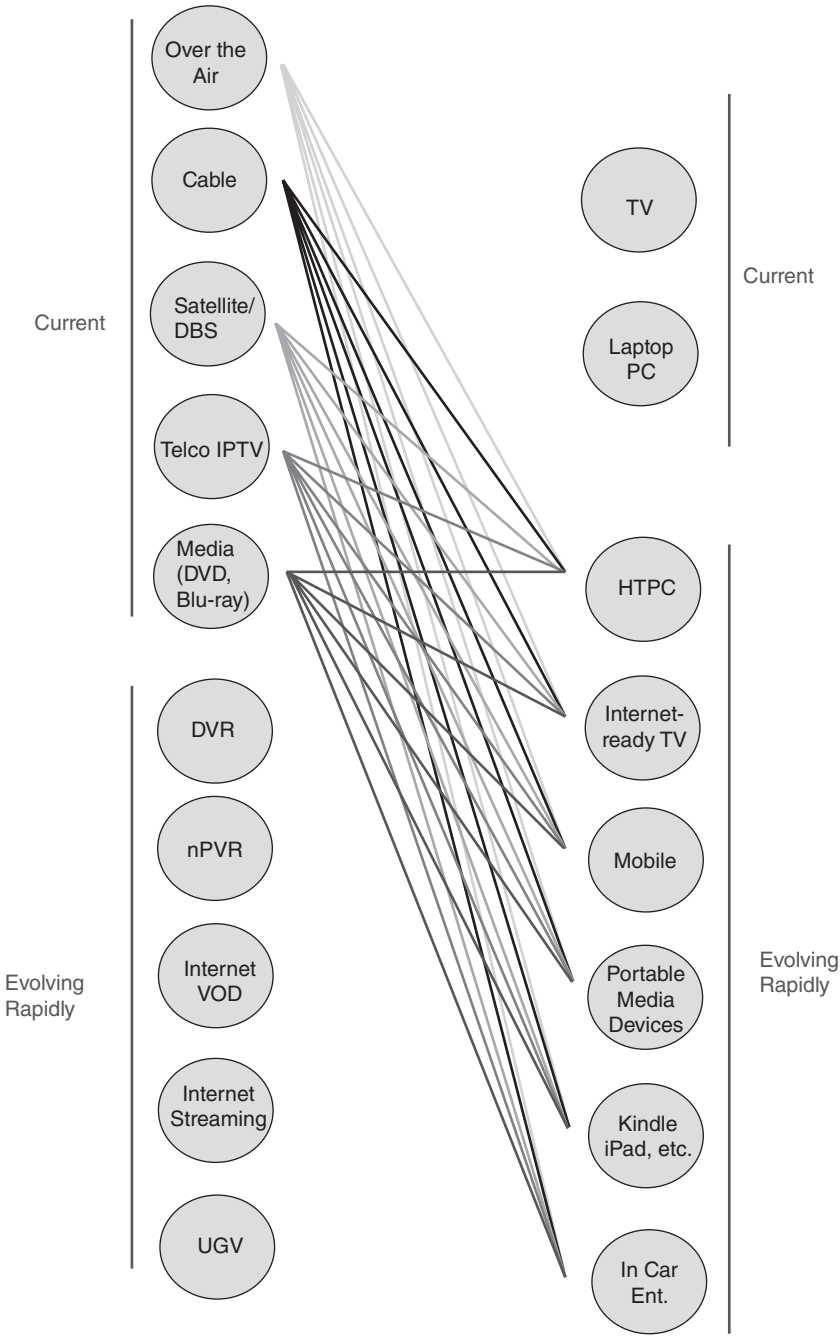

FIGURE 1.5 New consumer devices for traditional TV/entertainment video distribution.

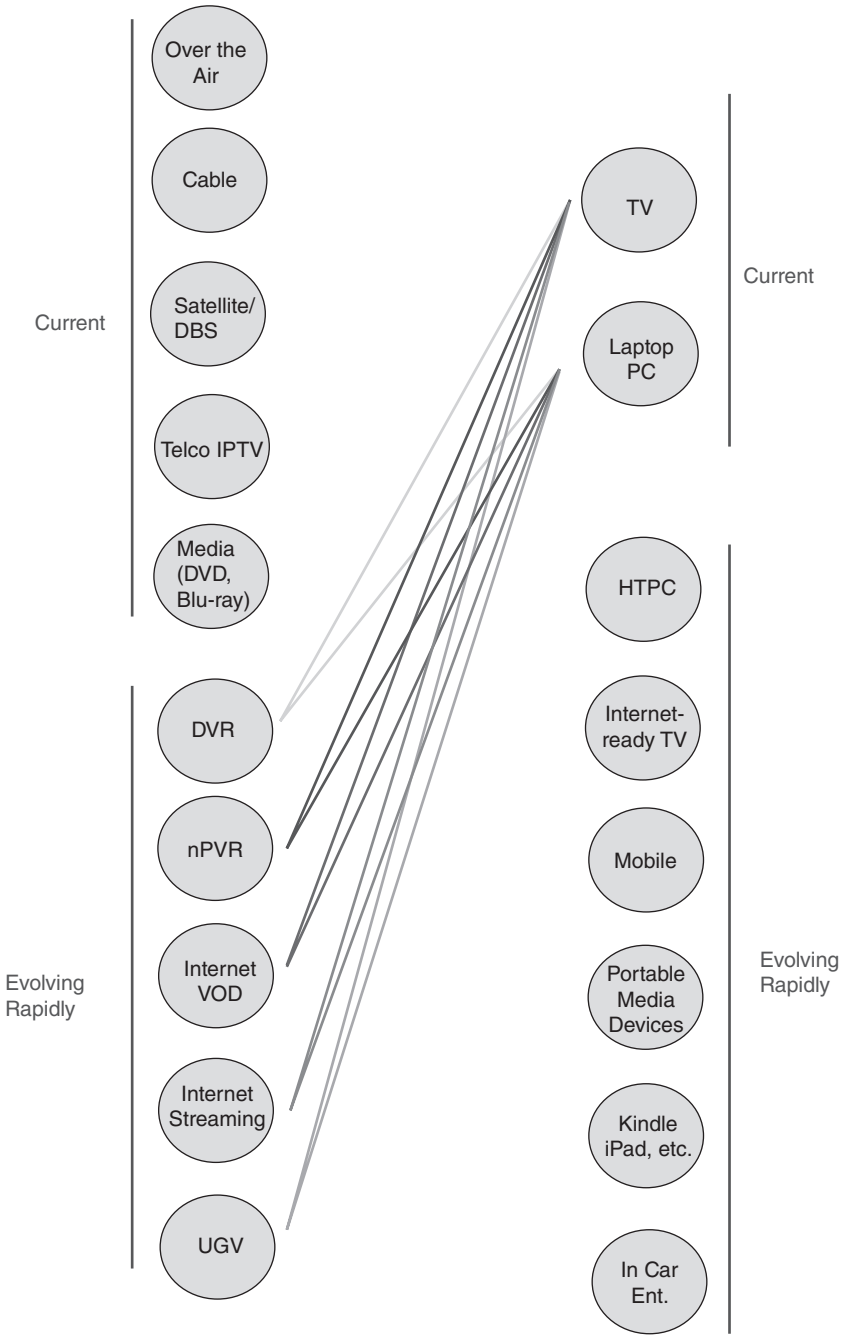

FIGURE 1.6 New sources of video content for traditional viewing devices.

where the most severe and disruptive changes to the incumbent service/content/distribution providers is likely to occur.

Figure 1.7 depicts new sources of video content for newer viewing devices. This set of evolving interfaces are perhaps the most distinct from the others identified so far; however, since the infrastructure supporting these interfaces is in a development stage, the overall impact on incumbent providers is somewhat limited. Nonetheless, the sheer quantity of interfaces and sinks should reinforce the technical and business opportunities for providers and technology developers.

Ultimately, one can view content delivery as being a *push mode* or a *pull mode*.

- Traditional broadcast TV can be seen as a *push mode* technology: the broadcaster pushes the content out, although the receiver can filter it, namely he/she can choose what subset of the pushed content is viewed at any point in time. The number of channels broadcast (both over the air and by cable TV providers) is by the hundreds.
- IPTV can be seen as a *basic pull mode* technology: the receiver selects the multicast group he/she wants to join and thus select/pull/receive content. The number of multicast groups/channels is the thousands.
- Internet/web TV can be seen can be seen as a *pure pull mode* technology: the receiver selects the file he/she wants to download (from a site such as YouTube), and, thus, select/pull/receive the content. The number of downloadable files is the tens or hundreds of thousands, and the number of combinations (sequences) of different content arrangements is $n!$, where n is the number of available files.[9,10] The viewer can compose his/her own sequenced entertainment (some may even call it "his/her own production").

Note: Stirling's approximation to $n!$ is

$$n! \approx n^n e^{-n} \sqrt{2\pi n}.$$

For example,

n	$n!$	$n^n e^{-n} \sqrt{2\pi n}$	Error (%)
10	3628800	3598696	0.83
100	9×10^{157}	9×10^{157}	0.083

[9]For example, someone liking tango music/dances could identify, say, 20 clips on YouTube (or some other service), place these URLs in a PC file, and "play them once in a while" either in the linear sequence A, B, C, D, and so on first identified, or in any combination thereof: B, A, C, D; or C, A, D, B, and so on, and so on.

[10]Actually, one could play the same clip multiple times. In this case, the number of combinations is n^n, which is, in fact, larger than $n!$

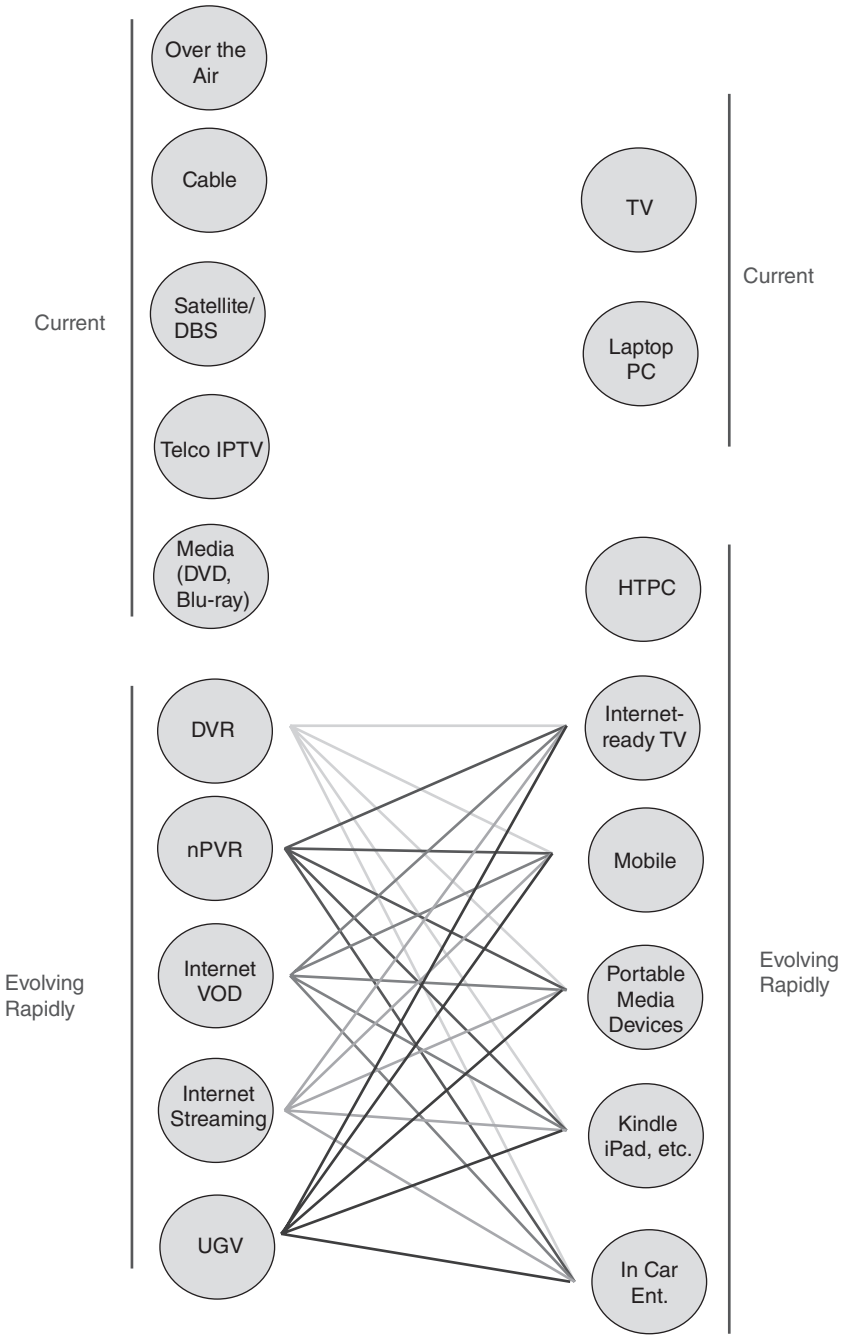

FIGURE 1.7 New sources of video content for newer viewing devices.

Some argue that with a much larger variety of content available in the Internet TV/Web TV content, even the traditional ways of using multicast and broadcast (essentially a single stream everyone watches at the same time) become less relevant. However, in this text, we hold to the principle that multicast is and continues to be a viable mechanism for content distribution for a basic pull-mode paradigm (i.e., for linear TV–VoD may continue to relay on unicast.)

1.3 TECHNOLOGY TRENDS (SNAPSHOT)

As implied in earlier sections, the basic elements of the service under discussion are (1) the content and techniques and technologies to store it; (2) the platforms and networks for distribution and reception of the content; and, (3) the customers, and their changing consumption habits. Some of the major video distribution technological drivers of the decade are seen as including IPTV, HDTV, 3-Dimensional TV (3DTV), inexpensive storage, Widgets, Fiber To The Home (FTTH), super-high-speed Internet backbones, and DVB-T2/DVB-C2/DVB-S2. Synergistic integration of the Internet and TV has been sought for the past 15 years, so far with limited success for a variety of reasons, including limited Internet access bandwidth. However, this process now appears to be picking up momentum, driven by the increased availability of bandwidth and the commercial desire to bring new services to the viewing public. Some of these technological trends are highlighted below.

The key underlying technology for NTTV is IP. Hence, our emphasis and focus of the book on IP in general, and IPv6 in particular.

New technologies and approaches include DVR systems (whether based in the home or in the network) and new IBTV streaming services, such as iTunes (iCloud), YouTube, Microsoft's Xbox, Netflix, Amazon's Video on Demand, Hulu, and Vuze. Some firms are being described as "*Reinventing TV Online*" [AXO200901]. New TV models that come to the market with software, known as widgets, that makes it easy to access Web content on TV sets using the remote control device rather than a computer keyboard. Observers state that [WIN200901]

> You are going to see very broad adoption of this open technology by the best brands in the TV industry—not just for specialty products but deeply penetrated in their product lines. . . . Of course, similarly optimistic statements have been made by industry executives since the mid-1990s, when efforts to combine Internet technology with TV sets first emerged. The current economic climate could be another stumbling block, deterring consumers from upgrading their existing TV sets. Still, the topic remains a hot one in high-tech circles because of the potential impact on existing business models in the entertainment industry. Instead of the often expensive packages of video content from cable and satellite providers, the Internet could theoretically deliver a much wider array of entertainment and information choices—many of them free . . .

Observers further note that [THO201101]

> Consumer spend on DVDs is in terminal decline, and the lack of mainstream consumer interest in Blu-ray as a format means the trend has not been halted, let alone reversed. Yes, in most markets, physical sales still dominate the paid video content market, but retail prices—and sales—are heading in one direction—down. In countries like the UK, there are few shops now even selling DVDs, while Amazon, the primary online retailer, has plans to convert us all to digital rather than physical content… in the absence of a legitimate alternative, consumers continue to access digital TV and movie content illegally. Yet, as Netflix has demonstrated in the U.S., when consumers are offered a legal, convenient alternative, many are happy to pay for it. In Europe we do not have that choice, and will not have until the likes of Fox actively encourage and accelerate the development of legal digital distribution services. As we have seen with the music industry, if you invest too much in squeezing the last drop out of a declining format, without investing enough in creating the digital alternative, you risk being stranded, rendered irrelevant by consumers' changing tastes.

Consumer surveys show that traditional TV will need to reinvent itself to satisfy their viewers' demands, including interactivity, Internet presence/distribution, and new programming. The range of entertainment options—including YouTube clips, online games, and pirated movies and TV shows—is luring eyeballs away from traditional television. Audiences increasingly look for niches, for example TNT, Bravo, and so on. As audiences continue to fragment, the ability to secure advertisers gets harder [GRO200901]. These trends speak to multicasting approaches (rather than broadcast) and/or on-demand sites. With regard to UGV, everyday, 100 million users watch videos on YouTube; this adds up to 3 billion watched videos each month (9 billion minutes, if each video is 3 minutes long, on the average—150 million hours[11]).

DVRs were being enhanced at press time to include Internet access, to create what one can call Internet-ready DVR. Table 1.4 defines some of the ancillary technologies that can be used to support time shifting [ITU200701]. For example, a press time announcement indicated that TiVo[12] subscribers were now able to display Internet content, music, and movies onto their television sets more easily with new hybrid devices (called TiVo Premiere); other DVR manufacturers, such as Boxee and Roku, already offered that hybrid feature.[13] TiVo has an intuitive interface, allowing the user to search both

[11]Note, however, that this is 150/45,000 = 0.33% of the total viewing time, even if one assumed that all the YouTube watching is from the United States, which it is not.

[12]TiVo was founded in 1997 and developed the first commercially available DVR. Its brand name became virtually synonymous with digital recorders and became a commonly used digital-age verb, much like "Google" and "blog." TiVo had about 2.7 million subscribers in 2009 (that is down from more than 3.4 million subscriptions in 2008).

[13]The Boxee Box (a $200 device) lets users search and store Web content and either play it on TV or share it on social-networking sites. Roku has also rolled out a digital video player (a $100 device) that integrates television, Web content, and a video library.

traditional cable channels and online content. It is stated that TiVo reportedly "*hopes the devices will help the pioneering DVR company shore up a slipping subscriber base by catching up with how digital-era consumers increasingly seek out entertainment*" [GRO201001]. The new boxes combine access to digital cable television, movies, videos on the Web and music, including a Pandora online music service.[14] The TiVo Premiere (initially selling for $299), had 320 GiB of storage and recorded up to 45 hours of high definition programming or 400 hours of standard-definition fare; the TiVo Premiere XL (initially retailing at $499), had a terabyte of storage and is be capable of recording up to 150 hours in high definition (HD) or 1350 hours of standard definition (SD). A new search function lets users browse for shows from premium cable channels and offer a new interface for broadband sources, such as Netflix, Blockbuster On Demand, and Amazon. It is been marketed by the firm with the following description "*It's the one box that can give you access to almost anything you want, whenever you want it.*" The italicized phrase above is important because it shows that vendors, providers, and infrastructure companies cannot stand still: if they do not keep up with the developments in technology, they may lose ground. Developers of hybrid (Internet-enabled) DVRs, hybrid (Internet-enabled) TV, and hybrid (Internet-enabled) STBs see these developments in these terms [GRO201001]:

> It's truly a game-changer . . . We're . . . bringing the creativity of the Web onto your TV screen.

TABLE 1.4 Technologies that Can Be Used to Support Time Shifting (Partial List)

Technology	Description
Personal video recorder (PVR)	An end user-controlled device that records, stores, and plays back multimedia content. PVR is also known as personal digital recorder (PDR). Also called digital video recorders (DVR).
Network personal video recorder (nPVR)	Same as PVR except that the recording device is located at the service provider premises.
Client PVR (cPVR)	An instance of PVR, where the end-user terminal device contains the recording capability that can be solicited and operated by end-users to record and store video, audio, and other associated data locally for subsequent playback.
Distributed PVR (dPVR)	Multiple instances of PVR, where a combination of cPVRs and nPVRs can be used to record and store video, audio, and other associated data for subsequent playback. A Home Network containing multiple cPVRs may use dPVRs in order to distribute storage of video, audio, and other data.

[14]The time may not be far off where the Pandora concept is applied to selection of video content (shorts).

Besides using a PC connected to a TV, or a CTV, Over-The-Top (OTT) streaming devices (also known as OTT set-tops) can be employed by viewers to watch their shows or programs via multimedia and open public networks (particularly, the Internet). OTT enable TVs, Smart TVs, STBs, PCs, tablets, and game consoles to receive and process streaming video. In recent years, OTT content from premium service providers, such as Netflix and Hulu, has become popular in the U.S. market. Apple TV[15] dominated the market for media-streaming devices: Apple TV (both the first and second-generation models) had about 55% of the media streamer market based on the number of units sold during 2010 (about 3.5 million media streaming devices were sold in 2010[16]). Some observers argue that several issues have contributed toward the success of these devices: they are compact, cost-effective, focus purely on streaming OTT content, and forgo large amounts of storage space to instead relying instead on flash memory [SCR201101]. Other observers have a different perspective since a press time report found that about four times as many respondents said that they watched video content on a TV via a PC, rather than from an OTT set-top (the survey of users found that 41% of those that view streaming video content on the TV use a PC, while 11% utilized a video streamer/OTT box); these observers conclude that the dedicated media streaming STB might not be around in a few years since it does not make sense when there are so many other devices in the home that do the same function (many other devices offer the same services—Netflix, Hulu, YouTube, and Vudu, among others—that the dedicated streaming devices do) [HAC201101].

Other new distribution techniques are also emerging. For example, superdistribution is a paradigm for distributing digital products such videos, music, books, and software, where the products are made publicly available and distributed (although in encrypted form) rather than being sold in brick-and-mortar store or online outlets.

Naturally, networks are at the base of all sorts of content distribution. As one example in the area of network access, Google announced in early 2010 that it was planning to launch 1 Gbps consumer Internet trials using Gigabit Ethernet technology. Google stated that it was planning to become a fixed-line carrier by building out an experimental fiber-optic network; Google was not expecting to be selling services directly to consumers, but instead was planning to be offering the network on an open access basis to multiple service providers with the network managed in an "open, nondiscriminatory and transparent way." The network was expected to cover only a limited geographic area; the baseline goal was for 50,000 people, but the firm published a potential reach

[15]Apple TV is a digital media receiver developed and sold by Apple; in 2010, the company announced a second-generation version of the Apple TV that can stream rented content from iTunes and video from computers or iOS devices.

[16]In 2010, Apple TV shipped 1.95 million units, or about 55%; Roku was second with the sales of 450,000 units, or about 13%. TiVo only sold 175,000 units, or about 5%. Some also include Logitech's Google TV, products from Iomega, Boxee, Western Digital, Sony, and Seagate, in this category; these vendors sold under 100,000 units [HAC201101].

figure of 500,000 people. The network was intended to spur innovation and was expected to be based in the high-tech regions (e.g., Silicon Valley headquarters). This trial was expected to add to pressure on carriers such as AT&T and Verizon to deploy faster networks; some of the older Passive Optical Network (PON) FTTH technologies being deployed by carriers do not provide very high-end speeds. Another objective was to use the deployment to test new ways to build out fiber networks, learning lessons that will be shared with other carriers around the world. Google notes that the project aims to see what application developers can do with the gigabit access speeds to create next-generation applications, for example, collaborative 3D lectures and under five-minute downloads of high definition films.

Yet another trend is user-generated content and the distribution of such content using social networks. For example, Twitter[17] and Facebook streams of the 2009 Emmys points, in the view of some, to the increasing irrelevance of staggered broadcast slots for the U.S. East and West coast: those on Pacific time now have to actively avoid social media or risk seeing spoilers [CAS200901]. As another social media example, in 2011, Google announced Google+, which is supporting Google's push into the social media. Standardization of IP-based delivery, especially in conjunction with social networks, is seen critical by industry observers. A quote such as the following provides a perspective on this new trend [DAW200901]:

> . . . Big shifts will pivot around how we connect to other people and "how we share the content of our lives with others." It's all about the social use of technology . . . Social networks will move towards being meshed or interconnected. They say private and public data will blur together and an advanced version of the social networks of your choice will be your browser of entry point. This is not the death of the traditional broadcaster but the role of terrestrial broadcasting of television will significantly decrease as the internet grows as a distribution system. Twitter set up the idea of sharing everything as we go; the next phase will be documented via sharing video . . . IPTV[18] [will] become a reality in most people's living rooms. One of the inexorable shifts in moving image viewing will be in distribution channels. Given the existing investment in broadcasting infrastructure this is not going to disappear in a hurry. But an increasing proportion of video content will be delivered over IP. Much or all of the content currently available on free-to-air will be available over IP, meaning it can be consumed across multiple devices and many situations. Managing that transition is perhaps the most prominent strategic issue of the next five years for TV channels . . .

In early 2010, Google and Intel teamed with Sony to develop a platform called Google TV to bring the Web into the living room through a new generation

[17]Twitter is a free service that lets a person keep in touch with people through the exchange of quick, frequent answers to the question: What's happening?

[18]The use of the term IPTV is this context is likely to mean all IP-based TV distribution system, including streaming and IPTV proper.

of televisions and STBs. These capabilities are an example of NTTV. Google TV is a TV platform that provides a new experience by combining TV, the Web, and apps, as well as providing a way to search across them all. Google TV seeks to unite all program searches under its own User Interface (UI). Google TV aims at providing an electronic programming guide (EPG) that harmonizes content from the Internet with a user's pay TV or free-to-air offering. Google TV provides a more direct hands-on experience of Internet TV than services based on OTT mechanisms, enabling access to the open web from the TV, and offering its user interface as the central hub for all TV content, whether linear, on-demand, or OTT-based [SCR201101]. Google TV was jointly developed by Google, Intel, Sony, and Logitech. With Google TV, Google and Sony envision technology that will make it as easy for TV users to navigate Web applications, such as the Twitter social network and the Picasa photo site, as it is to change the channel. Some existing televisions and STBs offer access to Web content, but the choice of sites has generally been limited. Google intends to open its TV platform, which is based on its Android operating system for smartphones, to software developers. The company hopes the move will spur the same outpouring of creativity that consumers have seen in applications for cell phones. Google is was planning to deliver a toolkit to outside programmers in early 2010, and products based on the software were planned for later in the year [BIL201001]. Google TV integrates Google's Android operating system and Google Chrome browser to create an interactive television overlay on top of existing Internet television and WebTV sites. There are two ways to get Google TV:

- on a standalone TV; and
- with a separate box, a digital media adapter (DMA), to use with current HDTV devices.

The Logitech Revue DMA, Sony TVs and Blu-Ray Disc players were the initial Google TV products available for retail. The DMA Revue was priced at $199 at press time. Dish Networks, who partnered with Google TV to use the search capability across its pay TV EPG metadata, has been offering the box at a flat $179 since launch to Dish subscribers.

New possible services available with some NTTV approaches also include the following:

- T-information (television information) (news, weather, traffic and advertisement and so on);
- T-commerce (television commerce) (banking, stock, shopping, and so on); and
- T-communication (television communication) (e-mail, instant messaging, Short Message Service (SMS), channel chatting, Voice over IP (VoIP), Web, multiple video conference and video phone, and so on).

Consumers may not appreciate the banners, crawls, and logos that clutter their TV screens, but they may be about to see a lot more of it. For example, in 2011, Comcast, Time Warner, Cox Communications, and other U.S. cable and satellite providers were planning to be introducing technologies that let them reach viewers with interactive pop-up ads. Cable companies have created a consortium called Canoe Ventures, which is retrofitting millions of digital cable boxes with software that lets advertisers send on-screen pitches. Bravo, USA, History, and about a dozen other U.S. channels have signed up for the service. Rovi, a U.S. provider of on-screen program guides, has developed its own T-commerce technology and signed up major networks, including NBC and Fox. Samsung, Sony, and other television makers reportedly plan to offer similar services on Web-connected TVs. Satellite operators Dish Network and DirectTV were planning to create their own systems. Ultimately, users may get targeted pitches tailored to their viewing habits. Adopting T-commerce could create new commercial opportunities for cable companies. T-commerce efforts to date, however, have not been a huge financial successes. For example, TiVo boxes deliver interactive pop-ups, although so far they have been used mostly as a way for viewers to request brochures or other information; British Sky Broadcasting has had T-commerce for a decade, also with limited success [EDW201101]. The expectations were that given the scale of the new initiative, it will be more successful.

1.4 REVENUE-GENERATION TRENDS

The new content distribution approaches discussed in the earlier sections also alter the revenue-generation model for content deliverers. Worldwide revenue derived by service providers and cable companies for IPTV, cable video, and satellite video services is forecast to grow to $234 billion in 2013; therefore, this industry segment is substantive [HEY201001]. Figure 1.8 illustrates an evolving NTTV network. Such networks can support new revenues for the service providers. Except in the case where the consumer purchases the video or movie outright, advertisement is the major vehicle for revenue creation. Table 1.5 depicts some typical (new) approaches, some of which were already hinted in the previous sections [REE201001].

1.5 GENERAL INFRASTRUCTURE IMPLICATIONS FOR SERVICE PROVIDERS

The key question of interest to many planners and researchers is "What will be the TV/content distribution model of the next 10–20 years?" The answer depends on the region of the world. In those developed and high-density, metropolitan locations where fiberoptic and broadband Internet services are readily available, (for example, in the East Coast and West Coast areas of the U.S.) there will be a gradual shift to IBTV/NTTV and/or also IPTV, with an erosion of the Cable TV delivery of TV-packaged content in favor of content

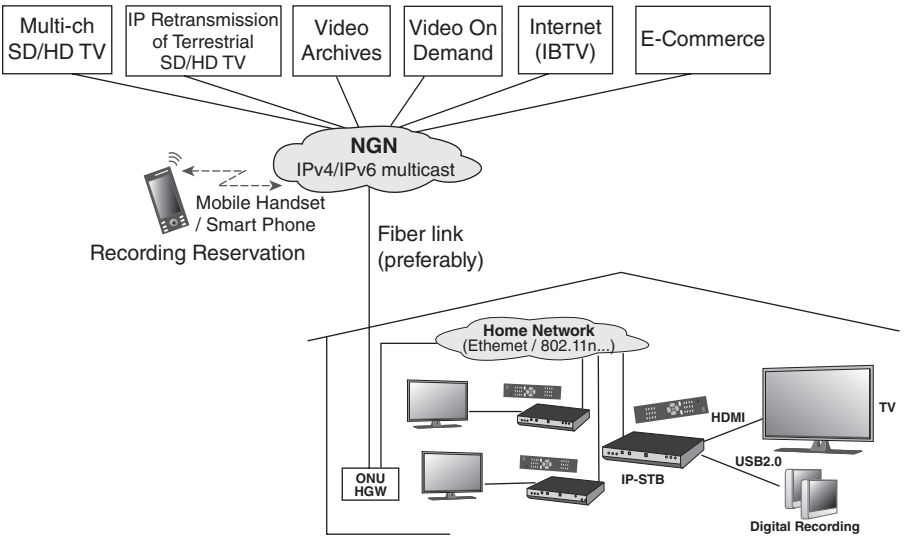

FIGURE 1.8 Example of network providing advanced video services.

provided via Internet service providers (ISPs) in the former case (IBTV/NTTV) and telephony carriers in the latter case (IPTV). In the central states of the U.S., DTH will continue to be important. Europe has had a strong DTH tradition for the past 20 years, and the Cable TV side has been underdeveloped. Hence, DTH will continue to be a strong factor in both Western and Eastern Europe, with IBTV/NTTV and IPTV in the wings. In the rest of the world (Brazil, Russia, India, China, and Africa), DTH will continue to be a strong factor for many years with IBTV/NTTV and IPTV in the wings, but further out in the future.

The infrastructure used to deliver content will have to be tuned to the evolving user-driven requirements. At the macro level, additional in-the-network storage and Internet streaming capabilities will be needed (additional in-home storage may also develop). Increased use of terrestrial IP-over-fiber connectivity will inevitably occur. Global IP traffic is expected to increase fourfold between 2011 and 2016, growing at more than 30% per year, with a large proportion of that expansion will be in the emerging markets [SOR201101]. Packet video delivery is now taking place over fiber (and wireless) infrastructure that use IP Version 4 (IPv4) streams. The expectation is that by the mid-decade and beyond, infrastructure based on IPv6 in general, and IPv6 Multicast in particular, will be the desired canonical approach to video distribution for NTTV, especially to support the migration from broadcast to multicast (and/or narrowcast) and from linear to nonlinear video consumption paradigms. Multicast supports communication between a single sender and multiple simultaneous receivers. Content is streamed to a number distribution servers, usually operated by a network or service provider; these servers, in turn, stream the

TABLE 1.5 Video Ads and Approaches for IBTV

Approach	Description
Ad overlays	A small, semitransparent overlay across the screen (usually on the bottom, but can be anywhere) of an online video, similar to what one often sees during TV shows. These ads usually show up 15 seconds into the videos they are on, and last for 10 seconds.
In-banner video ads	Approach that leverages the banner space to deliver a video experience as opposed to another static or rich media format. The format relies on the existence of display ad inventory on the page for its delivery.
In-page video ads	Approach where ads are delivered as a standalone video ad and do not generally have other content associated with them. This format is typically home page or channel-based and depends on real estate within the page dedicated for the video player.
In-stream video ads	Approach where ads are played before, during, or after the streaming video content that the consumer has requested. These ads cannot typically be stopped from being played (particularly with pre-roll). This format is frequently used to monetize the video content that the publisher is delivering. In-stream ads can be played inside short- or long-form video and rely on video content for their delivery. There are four different types of video content where in-stream may play: UGC, Syndicated, Sourced, and Journalistic.
In-text video ads	Approach where ads are delivered from highlighted words and phrases within the text of web content. The ads are user-activated and delivered only when a user chooses to move their mouse over a relevant word or phrase.
Monetized video	Online videos that generate revenue by themselves. This is usually accomplished by advertisements in and around the video content, but can also be accomplished by charging users to watch, download, or subscribe to the videos.
Nonlinear video ads	An ad product that runs parallel to the video content such that the user still has the option of viewing the content. Common nonlinear ad products include overlays that are shown directly over the content video itself, and product placements that are ads placed within the video content itself. Nonlinear video ads can be delivered as text, graphical banners or buttons, or as video overlays.
Overlay ad	A banner ad that appears in the bottom 20% of the video window. Click action initiates a linear video spot or takes the user to a website. Sold to advertisers on a Cost Per Thousand Impressions (CPM) basis and/or Cost Per Click (CPC) basis.
Pay per click (PPC)	Online advertising payment model in which payment is based on qualifying click-throughs. The content publishers get paid a set rate for every click on the advertiser's material.
Skin ads	Advertisements that appear in a video player skin, that is, the graphics surrounding where a video plays.

content forward to users. Multicast is ideal for linear video distribution but is not by itself ideal for VoD; hence, a service provider should plan to support (IPv6) multicast for linear TV and (IPv6) unicast for nonlinear TV (including VoD). Peer-to-peer technology may also be used; some researchers in fact argue that IPv6 protocol can provide an excellent environment for P2P-based applications (a press time study found that 61% of IPv6 traffic is P2P-related—but IPv6 traffic is still just 0.03% of total Internet traffic [MOY201101]). P2P concepts are not the focus of this book and are only briefly surveyed.

We are not implying here that the various NTTV linear/nonlinear services (VoD/CoD, TSTV, IPTV, UGV, Connected TV, and so on) can only be achieved using IPv6 Multicast. In fact, these services are already being delivered today over IPv4/IPv4 multicast infrastructures. The point of this treatise is that deployment of IPv6 will eventually overcome IPv4 under any number of metrics (number of users, number of sites, amount of traffic, and so on), and, therefore, it is important to be ready for that infrastructure deployment, both in terms of "migrating to it," but much more importantly and profitably so, "how to take strategic advantage of the new technology and gain market share and/or enter new markets."

Impacted and/or interested industry players include the following:

- Content providers
- Application providers
- Content aggregators
- Service providers
- Network providers
- Consumers (subscriber, viewer, and so on)
- Standards developers
- Regulators

True innovation is required by providers to survive this major shift and not stagnate; such innovation must be bold to deal with the potentially business-risky consequences of an unflexible continuance of the status quo. Naturally, service providers do not want to obsolete their networks and infrastructure over night, but prefer to evolve them to support the new commercial requirements. Such evolution must be well planned, well thought out, and well executed.

HD services (based on MPEG-4) will require about three to four times the bandwidth of SD services (based on MPEG-2). Emerging Ultra HDTV provides 16× the resolution of HDTV (7,680 × 4,320 pixels), but needs a bandwidth of 100–200 Mbps. If 3DTV takes off, it may increase the bandwidth requirement by 25–50%. However, there are new compression technologies, such as fractals and wavelets, that if perfected and become cost-effective, will decrease the bandwidth requirement by an *order of magnitude or more*. While this is very advantageous to IP-based service providers, it will be a major future challenge to bandwidth-only providers.

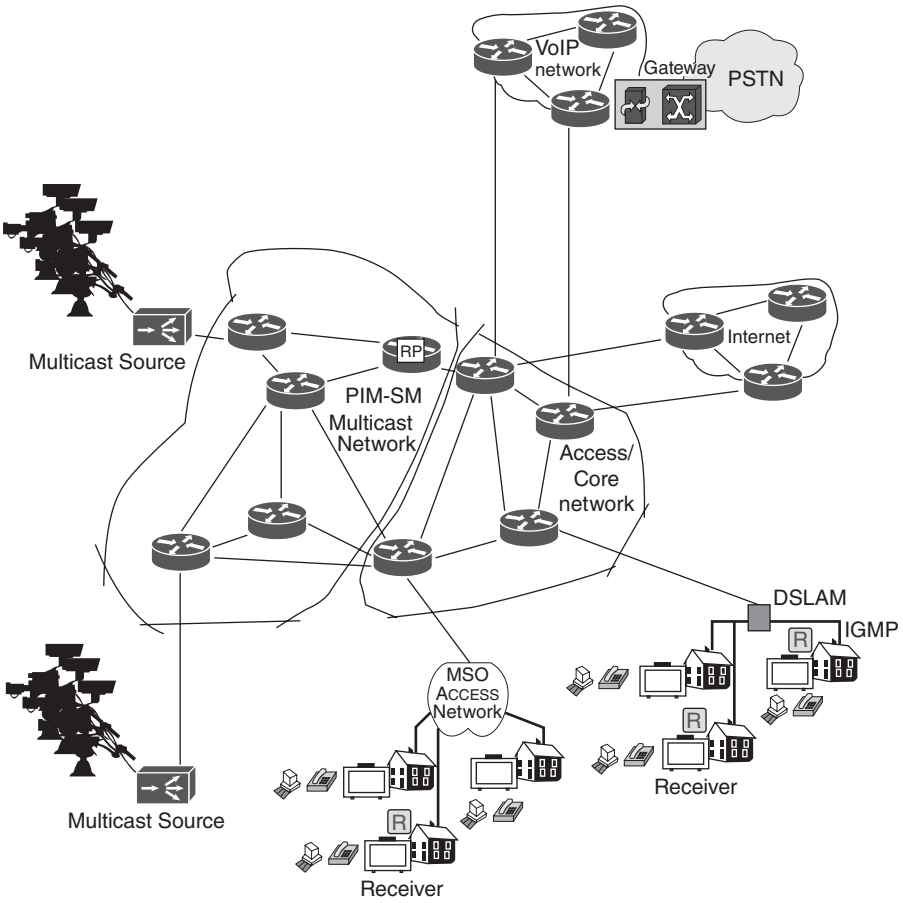

FIGURE 1.9 Illustrative example of triple play IPTV-based multicast network.

Providers also need to consider "triple-play" architectures to support video, Internet, and voice services, although the latter may not necessarily be the big "money maker" (we do not focus on wireless cellular and other mobility services in this text.) Figure 1.9 provides a simplified illustrative example of a "triple play" network; currently such network may be IPv4 based, but the evolution is toward an IPv6-based environment (for all services, or at least a subset thereof.)

It is also clear that satellite providers will have to support a service that encompasses a migration to a hybrid-based delivery mechanism that makes strategic use of both satellite- and fiber-based transmission resources [MIN199101], [MIN199201], [MIN199401], [MIN199501], [MIN199801], [MIN200201], [MIN200202], [MIN200301], [MIN200701], [MIN200801], [MIN200901], [MIN201001], [MIN201101]. Increased support of Internet services, for example, by using Medium Earth Orbit (MEO) assets that

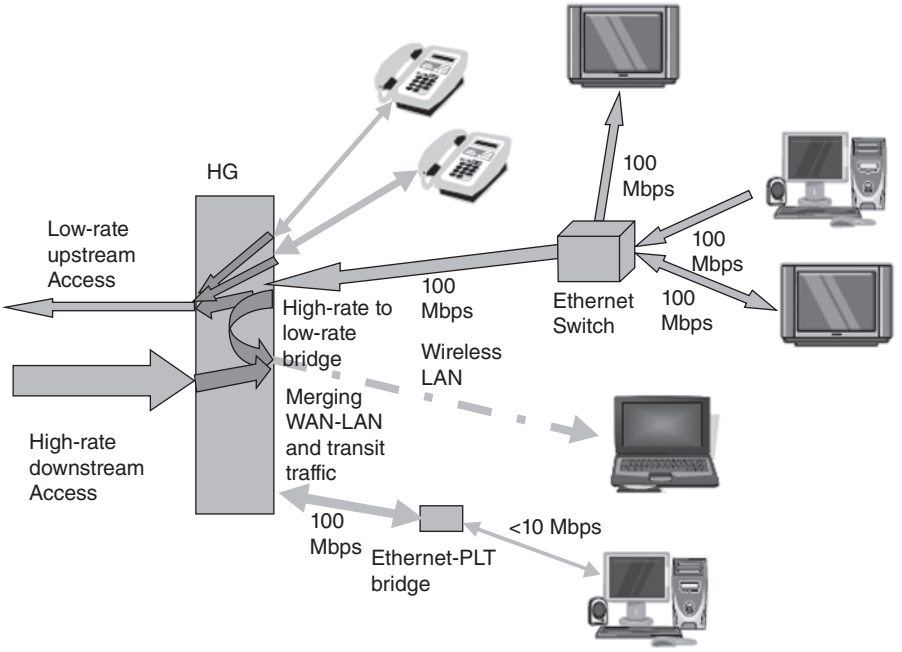

FIGURE 1.10 The evolving home network, as described in the home gateway initiatives.

significantly reduce the roundtrip latency (such as the O3b Networks model), will be advantageous in this context. For example, O3b Networks, a venture of Google and others, is building a new satellite-based, global Internet backbone for telecommunications operators (telcos) and ISPs in emerging markets. O3b's satellites will be placed into orbit approximately 5000 mi from earth, four times closer than geostationary satellites, speeding up Internet connections through its inherent low latency [SOR201101].

The in-home network is also becoming fairly sophisticated, as noted in Figure 1.10, as recognized by the Home Gateway Initiative [HGI200601]. Service providers, network providers, and content providers need to be cognizant of the evolution occurring in the home environment; for example, the direct connecting of TV sets to the Internet, and the implications thereof.

While there is an expectation of transition in viewer habits with ensuing impacts on the delivery infrastructure, one should keep in mind, at the same time, that the current decade has seen and may continue to see some economic difficulties. It follows that, perhaps, not much new infrastructure might be deployed to compete against existing infrastructure in the next 2–3 years. For example, U.S. Cable TV companies may not immediately deploy a lot of new fiber routes, implying that they may continue to use satellite distribution to headends dispersed nationwide instead of migrating rapidly to terrestrial dis-

tribution, at least until the second half of the 2010 decade. The same may occur in reference to the developing world: companies may not deploy a lot of new WiMAX towers to provide local distribution of TV signals, implying that that consumer will continue to use DTH satellite services instead of migrating to terrestrial distribution (as rapidly). While free TV channels are putting their content online with increasing regularity, pay TV channels are more reserved. To date, many pay TV channels have rather limited online video offerings. Thus, while the majority of the key content continues to remain available only on pay TV, the operators (Cable, satellite, IPTV) will hold the customer base; observers are forecasting that by 2015, there will be an additional 150 million pay TV homes globally [SCR201101]. Nonetheless, the expectation is that fiber deployments to support IP, IP Multicast, IPTV services, streaming, and NTTV will continue to make inroads and be dominant by the decade's end or soon thereafter, at least in the industrialized nations of the world, with the exception perhaps of the BRICA countries (Brazil, Russia, India, China, and Africa).

While the theme of this text is the evolving and increasing consumption of IP-based video, delivered either via terrestrial IPTV-based systems or via the Internet in some areas of the world, one needs to note that the consumer landscape can be segmented into the following areas: urban, suburban, exurban, rural, undeveloped. Each of these market segments makes optimal use of different technologies, or at least is at a different deployment cycle and lags behind the other by a number of years (see Figure 1.11) Hence, there will continue to be a key role for satellite-based DTH systems for many years to come and for large shares of the global population, especially outside North America and Europe. Both IPTV and IBTV require, to a large degree, the deployment of FTTH in order to consistently provide the kind of bandwidth required for this delivery mechanism. As a side note, a press time report from Eurostat, the EU's statistical agency, showed that almost a quarter of the European Union's 500 million people have never used the Internet, and there is a widening division between the web-savvy north of Europe and the poorer

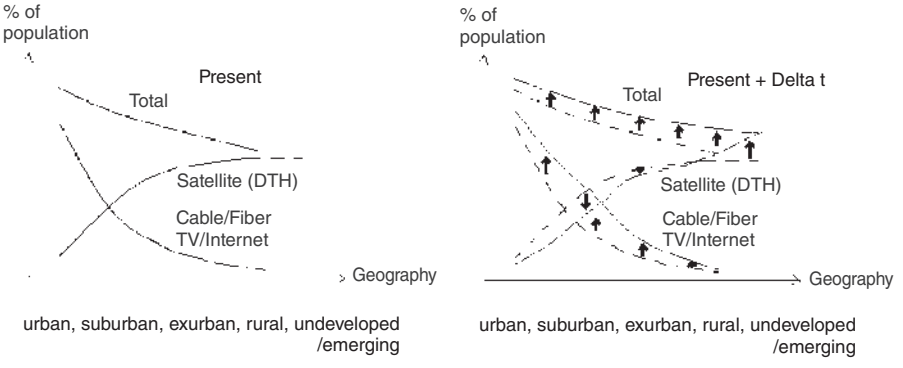

FIGURE 1.11 Various geographic markets and applicability of various technologies.

south and east. More than half the population of Romania and just under half of those in Bulgaria, Greece, Cyprus, and Portugal do not have Internet access at home. Besides highlighting geographic disparities across one of the world's most-developed regions, the figures underline the lack of opportunity people in poorer communities have to take part in advances such as the Internet that have delivered lower cost goods and service to millions of people. The report noted that 24% of 16–74 year olds across the 27 countries in the European Union have never accessed the Internet. Although overall Internet access has risen in the past 5 years, the range is still wide, with just 45% of the population connected in Bulgaria compared with 94% in the Netherlands; others in the top tier include Luxembourg, Sweden, and Denmark, all with access rates of 90% or above. At the bottom end of the scale, 54% of those in Romania have never used the Internet, whether via home access, at an Internet café, or over a smart phone. Those countries with the lowest usage rates also tend to be those with the least number of fixed-line broadband connections [DAV201101]. These observations reinforce the fair-balance point above that while there is increasing consumption of IP-based video, delivered either via terrestrial IPTV-based systems or via the Internet, there will continue to be a key, even critical, role for satellite-based DTH systems for many years to come and for large shares of the global population.

1.6 SCOPE OF THE INVESTIGATION

We just noted that the infrastructure used to deliver content will have to be aligned to the evolving user-driven requirements. Infrastructure providers need to be keenly aware of the impact that these evolving viewer paradigms will have on their networks and even their revenue stream. These changes may impact broadcast TV companies, telephone companies (telcos) delivering IPTV-based services over fiber, satellite providers, and 3G/4G wireless network providers.

The themes discussed earlier in this chapter are amplified in the rest of the text. This work looks at the underlying technologies that support time shifting, broadband delivery, storage, and multicasting. The focus is on IP-based distribution, including IP multicast in general and IP multicast in an IPv6 environment in particular. It should be noted, however, that it is not the intention of this text to exhaustively address and analyze all new possible video and multimedia consumption trends now evolving, and the provider/infrastructure implications should such trends become ubiquitous, but rather to look at the major evolving trends and possible provider and network strategies. One should expect that the viewer trends in 2022 will be different from those of 2012; hence, what is of interest are the fundamental principles that enable one to build a flexible infrastructure that can easily accommodate future new services and delivery mechanisms—such fundamental approaches entail IPTV with IPv4/IPv6 multicast; here we focus on IPv6.

Following an introductory overview of the industry and trends, Chapter 2 provides a primer of IPv6. Chapter 3 discusses at IP multicast, while Chapter 4 focuses on IPv6 multicast approaches and challenges. Chapter 5 describes evolving video services that are of interest to consumers, especially for service-provider environments. Chapter 6 is an overview of IPTV, which is increasingly being considered to be the platform of choice for service-provider-based packetized video delivery. In addition to architectural considerations, some of the newly published ITU-T IPTV standards, including ITU-T H.701 (Error-Recovery), ITU-T H.721 (IPTV Terminal), ITU-T H.740 (Application Event Handling), ITU-T H.750 (Metadata), ITU-T H.761 (Ginga-NCL), ITU-T H.762 (LIME) and ITU-T H.770 (Service Discovery) are discussed. IPTV is indeed not the only platform for IP-based video delivery; hence, Chapter 7 looks indeed at those other platforms, such as streaming, Content Delivery Networks (CDNs), Peer-to-Peer (P2P) systems, cloud computing, and Internet backbones and access networks; the chapter also looks at the implications of these technologies and the evolving viewing habits in terms of the kind of network evolution that may be required to optimally support end-of-decade video services. Finally, Chapter 8 describes some of the new content sources (some of these services and/or providers may disappear over time and others will emerge, but we believe that the general trends discussed here, as a whole, will persist and prevail.)

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APPENDIX 1A BACKGROUND STATISTICS AND FORECAST

This appendix provides some primary data and projections. Useful recent time trend data is garnered from The Nielsen Company. We include both the data we had originally gathered when first conceiving of this project (2009), as well as the latest data at actual writing time (2011).

1A.1 2009 Viewing Habits Nielsen's Data

The 2009 data is from the *Television, Internet and Mobile Usage in the U.S., A2/M2 Three Screen Report, 1st Quarter 2009,* published by Nielsen [NIE200901]. Table 1A.1 provides actual data for recent viewing habits in the United States, which forms the basis for the projections we develop below. Figure 1A.1 provides a perspective in terms of the number of content consumers. Also, see additional data at the end of this appendix.

TABLE 1A.1 Actual 2009 Data for Recent TV Viewing Habits: Hours Spent Watching

Monthly Time Spent in Hours:Minutes Per User 2+				
	1Q09	1Q08	% Diff Yr to Yr (1Q09 to 1Q08)	Absolute Diff Yr to Yr (1Q09 to 1Q08)
Watching TV in the home[a]	153:27	150:38	1.9	2:49
Watching time-shifted TV[a]	8:13	5:52	40.1	2:21
Using the internet[b]	29:15	27:57	4.6	1:17
Watching video on internet[b]	3:00	1:57	53.2	1:02
Mobile subscribers watching video on a mobile phone[c]	3:37	n/a	n/a	n/a

[a] TV in the Home includes Live viewing plus any playback viewing within 7 days. Time-shifted TV is playback primarily on a DVR, but including playback services like Start Over as well as playback from a DVD recorder.

[b] Internet figures are from home and work. Hours : minutes for Internet and video use are based on the universe of persons who used the Internet/watched online video. All Internet figures are monthly averages over the course of the quarter.

[c] The average monthly unique users of mobile phones and mobile video in 1Q 2009 and 4Q 2008, based on Nielsen Mobile surveys and CTIA projection of U.S. wireless subscriptions. Video user projection, time spent, and composition data based on survey analysis of past 30 day use during the period. The mobile video audience figures in this report for 1Q 2009 and 4Q 2008 include mobile phone users who access mobile video through any means (including mobile Web, subscription-based, downloads, and applications). Projection of all subscribers is based on persons 2+. Projection of mobile video viewers, and all other mobile video estimates, based on subscribers 13+.

Source: The Nielsen Company.

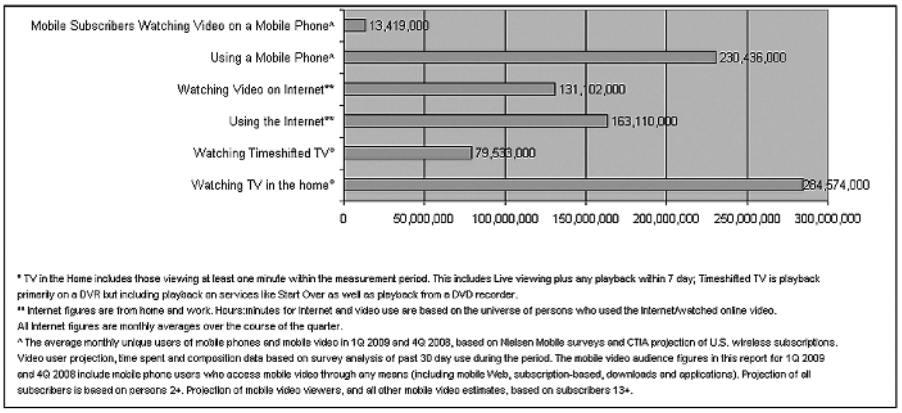

FIGURE 1A.1 Actual 2009 data for recent tv viewing habits: Number of people watching.

Observations included in the cited 2009 Nielsen report include the following:

- (fact) Television is still the dominant choice for Americans who watch video. Almost 99% of the video watched in the United States is still done on television.
- (fact) Traditional TV usage in the United States remains at an all-time high at approximately 153 hours a month. Of all demographics, adults age 18–24 show signs of using DVRs and online video about the same amount of time—they time shift television 5 hours, 47 minutes per month, and video on the Internet 5 hours, 3 minutes each month.
- (fact) Teens age 13–17 continue to be avid viewers of mobile video; they report viewing an average of 6.5 hours of video on their mobile phones each month.
- (trend) Time shifting usage with DVRs is up 40% from 2008, with Americans playing back 8 hours, 13 minutes per month.
- (trend) With broadband levels increasing in the United States, online video audiences will continue to grow as consumers begin to upgrade their PCs to support increased video consumption. Growth also hinges on how broadband channels promote themselves. As sites continue to aggressively market themselves, they will increase the levels of growth by creating demand.
- (trend) Mobile video viewing has grown a significant 52% in Q1 2009 from the previous year, up to over 13 million Americans. The most watched categories on mobile phones are comedy and weather.

These data are used to build a forecast of future trends. In Table 1A.2, some of the growth rates suggested by the study are used to project forward, but these rates are moderated substantially over time (e.g., while the growth rate for TSTV was 40% in 2009, we reduce that number to 5% by 2017). We take the overall growth rate of the aggregate all-TV home viewing hours to be 2%

TABLE 1A.2 Forecast for Transitions in Viewing Habits over Time (Parametric Forecast)

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Aggregate all-TV home viewing growth rate (%)		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Aggregate all-Internet home viewing growth rate (%)		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Total TV (calculated) (hour.)	156.0*	159.1	162.3	165.5	168.9	172.2	175.7	179.2	182.8
Total internet (calculated) (hour.)	30.0*	31.2	32.4	33.7	35.1	36.5	38.0	39.5	41.1
Super total: All TV viewing and all internet usage (hour.)	186.0*	190.3	194.8	199.3	204.0	208.7	213.6	218.7	223.8
Time shifted TV growth rate (%)		40.0	20.0	20.0	10.0	10.0	5.0	5.0	2.5
Internet TV growth rate (%)		50.0	40.0	40.0	40.0	30.0	30.0	30.0	30.0
Traditional TV home viewing (hour.)	145.0*	143.4	142.6	140.6	138.8	136.7	134.3	130.6	125.5
Time shifted/on demand home viewing TV (hour.)	8.0*	11.2	13.4	16.1	17.7	19.5	20.5	21.5	22.1
Internet-downloaded home viewing programming (hour.)	3.0*	4.5	6.3	8.8	12.3	16.1	20.9	27.1	35.3
Total TV viewing (all forms)	156.0*	159.1	162.3	165.5	168.9	172.2	175.7	179.2	182.8

*Actual data

a year, because people cannot continue to increase their entertainment time at infinitum—people also have to do productive work and attend to other family or related responsibilities. For the same reason, we take the aggregate all-Internet home viewing hours to be 4%. Figure 1A.2 depicts some of these trends graphically.

1A.2 2011 Viewing Habits Nielsen's Data

The 2011 data is from *The Cross-Platform Report Quarter 1, 2011* report published by Nielsen [NIE201101] Table 1A.3 provides the latest observations. Table 1A.4 compares 1Q2008 with 1Q2011; the increases for NTTV are conspicuous, supporting the fundamental theme of the text.

TABLE 1A.3 2011 Nielsen Company data on U.S. Watching Habits

	Q1 11	Q1 10	% Diff Yr to Yr	Hours : Minutes Diff Yr to Yr
Watching TV in the home	158:47	158:25	0.2	0:22
Watching time-shifted TV (all TV homes)	10:46	9:36	12.2	1:10
DVR playback (only in homes with DVRs)	26:14	25:48	1.7	0:26
Using the internet on a computer	25:33	25:54	–1.4	–0:21
Watching video on internet	4:33	3:23	34.5	1:10
Mobile subscribers watching video on a mobile phone	4:20	3:37	20.0	0:43

Note: Monthly hours of content consumption, per person in the United States over the age of 2.

TABLE 1A.4 2008–2011 Comparison of U.S. Watching Habits

Timeframe →	Q1 11	Q1 08			
Activities ↓			Delta	Total Percentage Increase	CAGR (%)
Watching TV in the home	158:47	150:38	8:09	5.41	1.77
Watching time-shifted TV (all TV homes)	10:46	5:52	4:54	83.52	22.40
Using the Internet on a computer	25: 33	27:57	–2:24	–8.59	–2.90
Watching video on Internet	4: 33	1:57	2:36	133.33	32.50

Coding for time spent on activity: H : m.

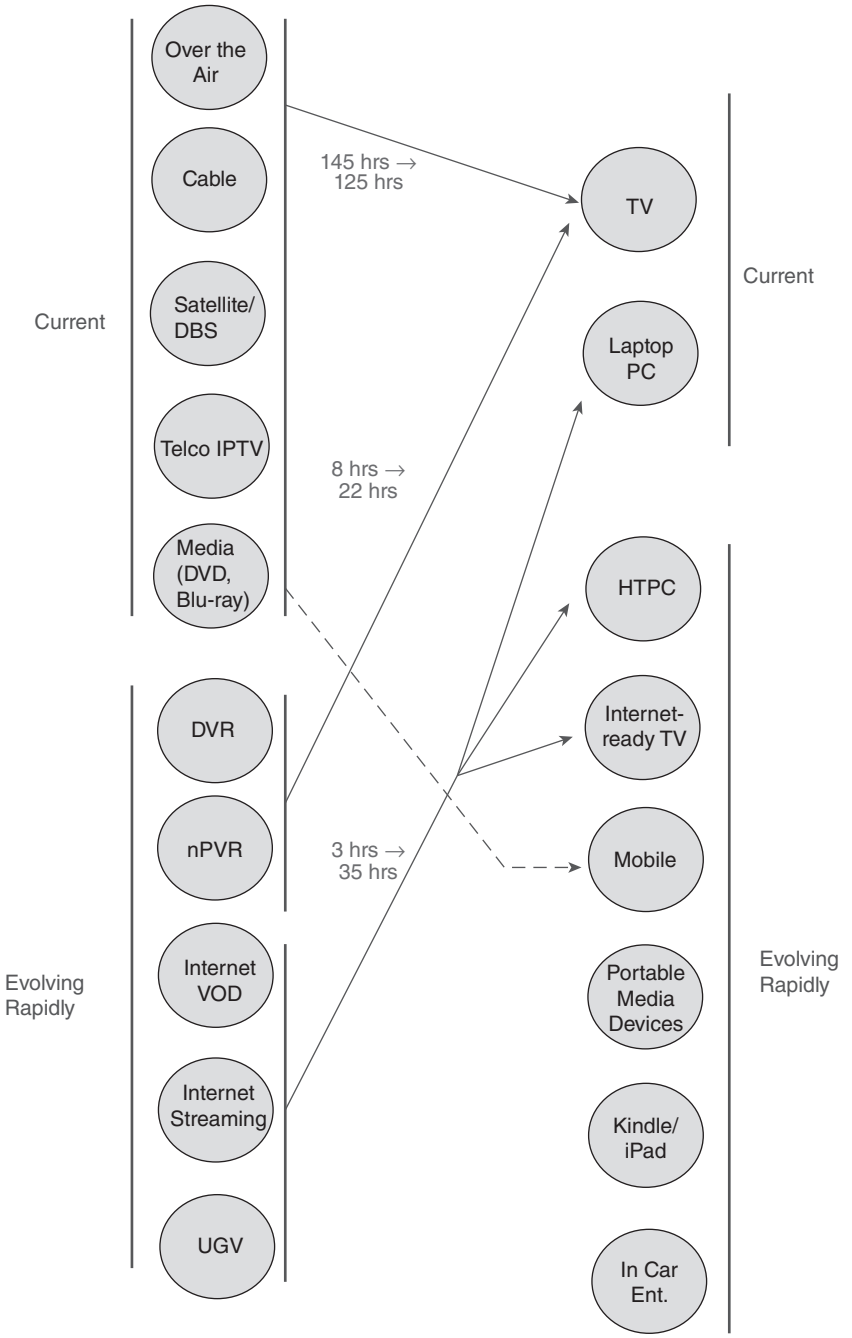

FIGURE 1A.2 Another view of shifts in viewing habits.