

If Fiber is the Medium, What is the Message? Next-Generation Content for Next-Generation Networks

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Abstract: The nature of content is critical for the economic viability of an ultra-broadband infrastructure. This article asks what types of media content we will have when we achieve widespread fiber optic networks. In the past, an expansion of transmission capacity led to a 'widening' of the TV medium. But the impact of ultrabroadband will be a 'deepening' of the content to a richer, more bit-intensive content. The study investigates, for 25 media, the price and capacity trends over the past century. It creates a model which shows the relationship of media prices per second over time, and the declining transmission cost per second and per GB. We find that the price people have been willing to pay for media entertainment per time unit has been fairly steady over a century, adjusted for inflation, at about 4.4 cents per minute. The price of distribution of content has been dropping at a compound rate of 8%. This enables us to identify the trend of bits per second delivered – the 'richness'- of the media over time. It grows at about 8% per annum. Projecting this rate permits us to predict the type, style, and genres of media content of the near future. It also enables us to determine the time when media will become visually richer than 3-D real life in terms of sensory experience.

Keywords: Broadband, NGN, NGA, Television, Content, Games, Film, 3-D, Cable TV.

■ The nature of Internet television

Marshall McLuhan memorably stated that "the medium is the message" (McLUHAN, 1964, p. 9), i.e., that the nature of the distribution system defines its content. If so, the next generation of the internet, ultrabroadband at gigabit rates over fiber optic networks, will have an impact on the styles of content. In this article I will analyze the types and styles of content most likely to emerge with this new technology of distribution. I will engage in a data-driven analysis of price trends of media consumption, distribution cost, and several other factors. This analysis will determine the historic rate by which media have become more bit-intensive and enriched in terms of sensory signals. Projecting this rate ahead permits us to predict the type of media content of the future.

The question of content is critical for any economic analysis of the viability of an ultra-broadband infrastructure. It is common to rush into talk of technology or rollout strategy without first considering the utility to users. If one builds an oil pipeline one must first be sure that there is an oil supply at one end and demand for it at the other. The economic case for investment in super-broadband must rest on its meeting a demand/price combination that is not satisfied today.

What would super-broadband connectivity be used for? There is no evidence for a major need for significantly more powerful types of email, website browsing, or professional at-home applications beyond basic-quality video. Ultrabroadband provides transmission rates of over 1 Gigabits per second, 50-500 times as fast as typical broadband rates of DSL or cable modem service. To what purpose then would many millions of residential users conceivably want the vastly more powerful connectivity of ultrabroadband? For residential households, the answer to this question has to be video entertainment, broadly defined.

But what kind of video would this be? If one asks even knowledgeable people what types of enhancements to video services a super-powerful internet pipe would produce, the answers normally include:

- more specialized and "long tail" programs,
- more individualized content,
- anytime, anywhere video entertainment,
- more user-generated content,
- more independent and foreign content,
- more interactivity and games.

Yet these answers are largely incorrect. Of course, ultrabroadband will be associated with these elements. However, they do not require upgrade to ultrabroadband transmission rates; regular broadband is sufficient. If the economic base of ultra-broadband rests on these applications it will fail as a new medium. Ultra-broadband capable infrastructure must be supported by different content applications.

And indeed, different generations of television technology have affected content. In the first generation of TV, when it was broadcast over a limited amount of spectrum, the number of channels was small and the resolution of its picture was relatively low and nationally standardized. Content was in consequence oriented to the broad center of the taste distribution, often described as the "lowest common denominator". It was characterized by content that was broad-based, middle of the road, middle-brow, national with

some localism added, and an advertising-based economic model. Because audiences were huge due to the limited number of channels, the budget for programming was substantial.

The subsequent second TV generation saw the development of cable, satellite, and home video for television. They allowed for the creation of an alternative TV transmission infrastructure. Today, advanced cable TV operates at about 1 Gigahertz. This is about twenty times as much as the typical seven over-the-air terrestrial channels. The extra transmission capacity was used first in a horizontal fashion - resulting in more channels employing the traditional technology of analog, 6MHz, one-way TV. Narrowcasting and long tail content emerged, and new channels included such highly specialized offerings such as the Anime Network, the Martial Arts Network, the Baby Network, and the Boating Channel. As audiences fragmented, content budgets dropped even for the bigger channels. Low-cost quiz shows, reality programs, and 'talking head' content proliferated. Theatrical films, both recent (for extra pay) and old became a staple.

The emerging third TV generation is mostly based on new transmission platforms. Internet TV (representing diverse content) and mobile TV (with ubiquitous availability) are the main components of this generation. The development of these new forms of TV was due in part to the increased transmission capacity on the last-mile access that came with broadband internet (using the transmission media of DSL over copper phone lines, coaxial cable, fiber lines, and broadband wireless such as Wimax). But the main distinguishing aspect of transmission was not so much in its overall increase but in its individualization, that is, the ability of each user to receive communications independently of other users. This is known as 'asynchronous' transmission, the opposite of the synchronous broadcast technology. Furthermore, the new type of communication permitted a return channel, i.e., it is 2-way. Broadband allows individuals not only to receive but also to create their own content transmission. Lastly, the cost of transmission of information becomes substantially distance-insensitive, thereby enabling a wider reach of content distribution than in the past.

Thus, the strengthening of transmission rates impacts content distribution and leads to it having much more of the following:

- More standard TV at different times. Services such as Hulu and Joost create free avenues for users to view regular broadcast content online and on-demand.

- Even more specialized programs for niche audiences than before. Examples might include TV from other countries; specialized feeds (i.e. "The Women's Field Hockey Channel" from the Beijing Olympics); and other types of long tail content.
- Global aggregation of nationally thin audiences.
- User-generated content such as that found on YouTube, Daily Motion, etc., even with a much lower quality of resolution.
- Increased downloading of movies. Studios are now considering downloads as part of their traditional release sequence, and some films may even be offered at the top of the sequence. Hindering these efforts, however, are fears of piracy as well as current low download speeds and low picture qualities.

In the extreme, narrowcasting might include programs tailored to the individual such as customized news programming; targeted advertising; or even personal plot lines with endings customized to taste. Different content modules can be assembled for different users. Viewer boredom could be measured to adjust the mix of "action" or "romance;" a soap opera could come equipped with different endings for either heterosexual or gay viewers. For all the diversity of such individualization, one must understand that it does not require any increase in transmission capacity at the edge of the network in its costly access network segment.

Why is that? Transmission is only one technology dimension underlying new style TV. A second one is the enhanced storage. This is often overlooked. With powerful and cheap storage, users can access a wide array of video content stored on many locations. The increased storage capacity and individualization mean that the nature of TV transmission changes. Instead of pumping to individuals hundreds of channels simultaneously, of which only one or two are actually watched at any given time, internet TV needs to send out only one or two channels at any given time to the user. This means that the transmission requirement of the end user at the last-mile access segment is actually not particularly high in comparison to the requirements of having hundreds of channels simultaneously transmitted. A household which uses simultaneously VoIP voice service, plus maybe two high definition TV channels, plus some gaming, requires no more than 35 Mbps (GIUNTA, 2008). This is about the rate available already to millions of households. User-generated content and peer-to-peer applications are similarly not reliant on large last-mile access transmission beyond those of regular broadband. Instead, these

require storage and a strong core network. Storage is required on both the user end and by intermediaries such as YouTube and Daily Motion. Similarly, online video games do not require ultrabroadband. Even seemingly complex interactive multiplayer games do not use all that much transmission capacity. On average, *Counter Strike* operates at about 40 Kbps. The limiting factor is the processing capacity on the central node, which restricts players' data stream.

Thus, the bandwidth of ultrabroadband - 1 Gbps and more - seems excessive for such requirements. What then would one use it for, if at all? Greater bandwidth creates two capabilities: the first is the *widening* of content options. This was discussed and described above. And the second is the *deepening* of content which is based on the increasing *richness* of content in terms of the bit rate of information supplied per time unit to human sensory receptors. The widening of content is a continuation of past trends. The widening pipes have successively resulted in more standard type channels. In the United States over 500 specialty programming channels operate. Still much larger diversity is provided through on-demand video, which enables an unlimited number of simultaneous programs to be available to a viewer.

What then will be the new style of content for ultrabroadband? The second expansion of television beyond the "*broadening*" of content - more choices among present type of content - is its "*deepening*." A deepening means content that is more intensive in sensory impressions, in terms of bits per second. It is, in sensory terms, a "*richer*" media.

The most obvious dimension of increased richness in video media is simply the increase in picture quality. The distinguishing factor between standard and higher definition displays has to do with the number of pixels per square centimeter, which allows a greater level of detail to be displayed. A standard display will possess 525 (or 625, depending on the country.) A high definition display (HDTV) provides twice that number; beyond that come so called 2K and then 4K TV (also known as Super S-HD, S-HV, or HiVision), with still more vertical and horizontal lines of pixels, a wider (1:2), more bits per pixel, and more frames per second. These new generations of picture quality represents an impressive move forward in the clarity of the moving image. Is such an advance truly necessary?

Traditionally, satisfaction levels in video quality have been shortsighted; each generation persuaded itself, and was persuaded by marketers, that it was using a technology that was life-like in video and audio quality. Each

generation eventually moved to higher levels of quality and soon wondered how it could have endured the past poor resolution.

The second dimension and driver in media richness is a product of larger screens. As digital displays become flatter than the boxy CRTs they can become larger, while homes and apartments remain roughly the same size. As a result people will sit at a wider angle to their screen and its pixels. This requires sharper pictures, i.e., a higher resolution such as 2K and 4K resolution, with a much larger number of pixels per square centimeter.

Three-dimensional displays, as well, will improve on the richness of the media experience. Technically many of its elements are already offered, and technologies that do not require the wearing of special glasses is on its way. Other sensory modalities beyond sight and audition might also find their way to an enriched TV content, such as elements of smell and feel. Vibration is already being set into home-theater seats. By the year 2020, Japanese researchers hope to release a commercial version of a 3D television with touch and smell features for an immersive virtual reality.

■ The economics of bits

All of the above trends of individualization and increasing richness of experience are interesting to note but have a pronounced technological ring. One is reminded of past scenarios envisioning a helicopter in every garage, electric power too cheap to meter, and other utopian scenarios. If the question is where residential fiber will take video media, the answer is not just technological but also economic. People will use more bits if their price drops. They will consume these bits by spending more time in the consumption of bits relative to other activities; and they will consume more bits per time unit, i.e. consume a 'richer' medium in sensory terms.

It is necessary to look at the underlying economics. To this end we now turn to bit cost trends. Willingness to pay for media is composed of two elements: the content cost, and the distribution cost.

[1] Price of Media Consumption $P(C)$ = Price of Distribution $P(D)$ + Price of Media Information $P(I)$

[2] Price of Media Information $P(I)$ = Quantity of bits $Q(B)$ x price per bit $P(B)$

[3] Quantity of bits $Q(B) = \text{Consumption time } T(C) \times \text{Bits per time unit (BpT)}$

Substituting, we get:

[4] $P(C) = P(D) + T(C) \times \text{BpT} \times P(B)$

We can express this as

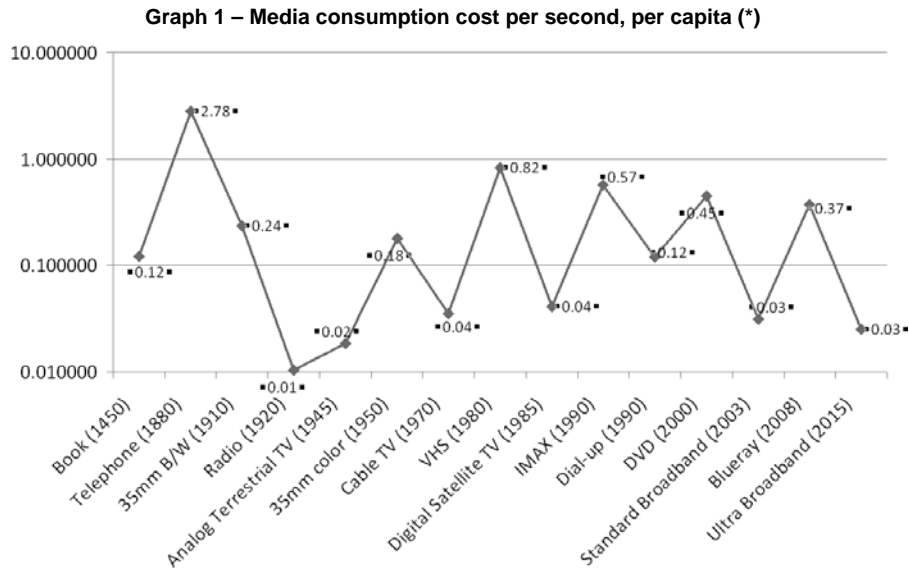
[5] $\text{BpT} = \frac{P(C) - P(D)}{T(C) \times P(B)}$

Equ. [5] expresses the bits per time unit of the medium, which is our measure for media richness, as a function of the price of media consumption per unit of time, the price of distribution per time unit, consumption time, and the price per bit. We now look at these components empirically. To do so we measure the prices and costs for various media, ordered by the time of their introduction plus a few more years for maturity to be achieved. And this is what we find:

First, the price $P(C)$ which people are willing to pay for entertainment has remained fairly constant over time, adjusted for inflation. It is approximately 0.1 cents per second, or about \$3.60 per hour. The rate of decline per year has been merely 0.5%. When the cost for individualized consumption is higher than such amount, people engage in sharing consumption, such as going to film theaters or watching broadcast television as part of a mass audience. When cost drops over time, people shift to individualized consumption for that medium, such as home video or pay TV. They share consumption for the still more expensive, often new, media, until they, too, become affordable.

Thus, the left hand of the above equation [5] shows almost no upward or downward trend for a century for consumer's payment for media per time unit, adjusted for inflation, even though several components of media cost have declined considerably. The price per second is about 0.073 cents per second. The growth rate is a faint 0.08 of one percent ¹.

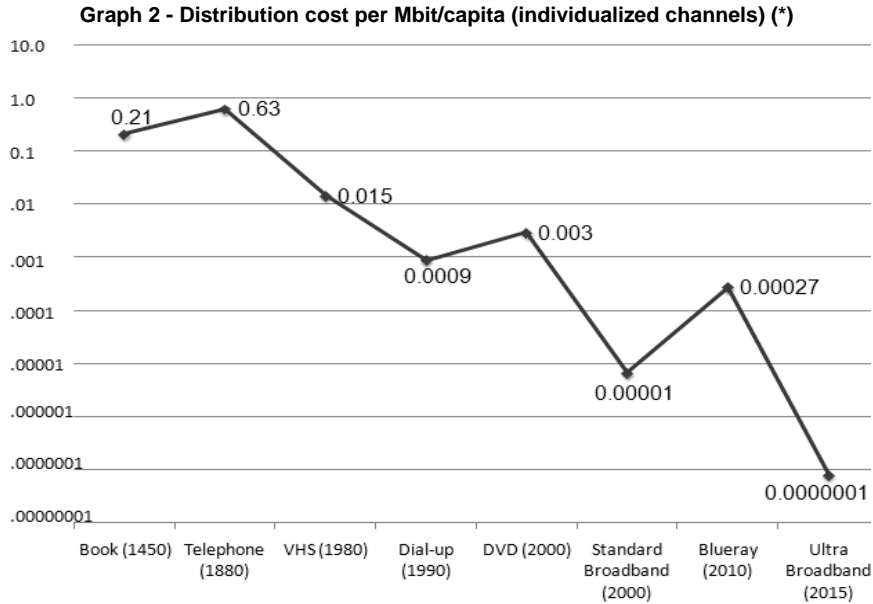
¹ Here and subsequently, the estimated OLS regressions are $\ln Y = a + b \ln t + u$, where t is time.



(*) We identified the historical prices for different mediums per media unit (e.g. price for one book, record, DVD,, etc.), or per monthly subscription rates plus cost of time if the medium incorporates advertising. Historical prices are adjusted for inflation to 2008 dollar equivalents. We divide by the time spent with each medium or media product. We arrange the media by their time of appearance as a consumption item.

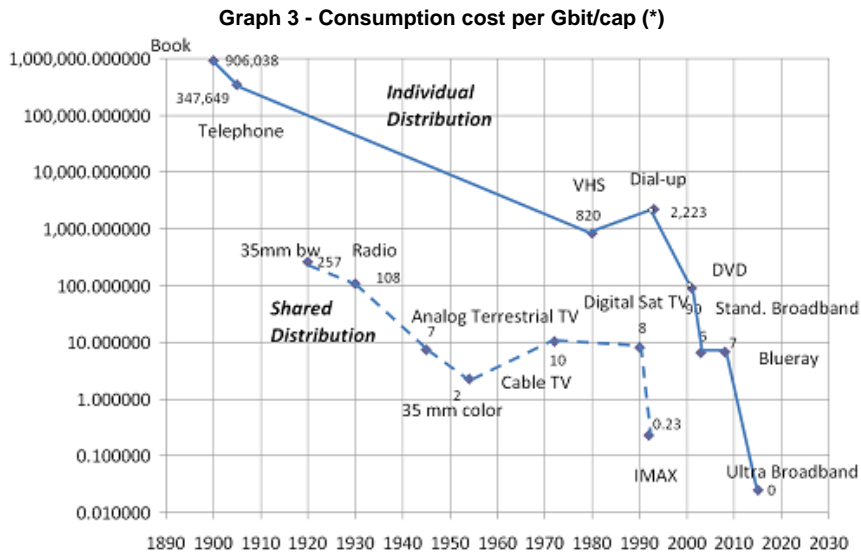
Of the right hand elements of equation (5), the price of distribution $P(D)$, as measured in the price of transmission of bits per second, has declined enormously over time. See Graph 2.

It has declined at a rate of 9.68 % per year since 1880. With this cost component dropping rapidly, and with the willingness to pay per media time unit stable ($P(C)$), the component of payment for the information itself ($P(I)$) has been able to rise. This consumption could rise both in terms of time units ($T(C)$) and in the consumption of bits per time unit BpT . The former has not risen much, given the reality of work, transportation, sleep, and other time consuming necessities of life. According to studies such as those by the media investment bank Veronis Suhler Stevenson, media consumption is 9.67 hours per day, or about 3,530 per year (Veronis Suhler Stevenson, 2007a). This includes multitasking with other media and other activities. It is hard to imagine how much extra time there could be allocated to media consumption. Indeed, in 2006 that number even declined slightly, according to the US Census (Veronis Suhler Stevenson, 2007b). Over the past decades, media consumption time has risen only modestly even if its composition has changed. It has risen only 15 percent over the past three decades, for an annual compound growth rate of 0.47%.



(*) The distribution cost per media product is divided by the Mbit per unit of each media.

Meanwhile, the price per bit has declined sharply, as can be seen in Graph 3. Applying a regression, we find that it has declined by an 8% compounded annual growth rate.



(*) The cost per sec (see graph 1) is divided by the Mbit/sec) transmission rate.

If we put these elements together, we observe that what has risen then is not the time units of media consumption but their quantity per time unit, in terms of bits. Media enrichment can be calculated by equation [5].

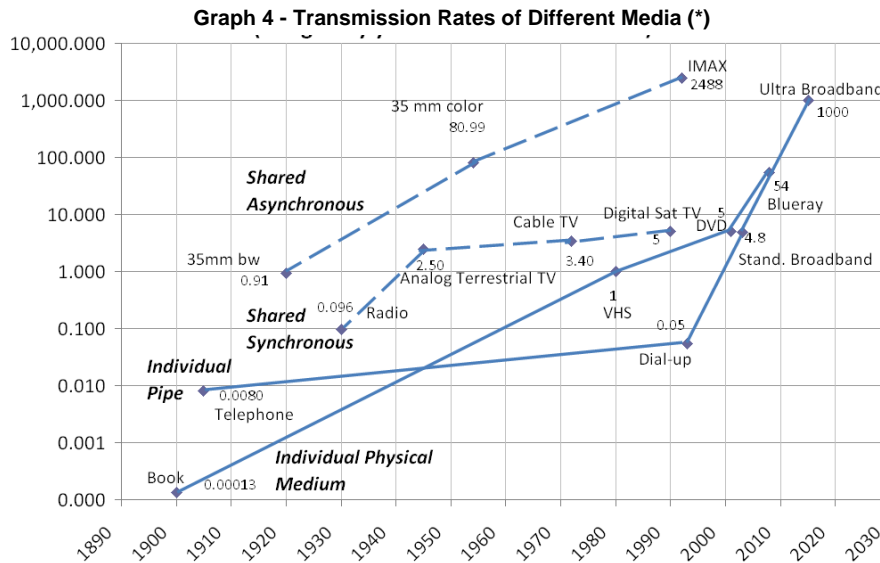
$$[5] BpT = P(C) - P(D) / T(C) P(B)$$

We can express changes logarithmically:

$$[6] \ln BpT = \ln[P(C) - P(D)] / \ln T(C) - \ln P(B)$$

$$= -2.15 - .47 - (-8.0) = 5.38$$

Thus, the consumption of bits per time unit of media use has risen, by this calculation, by a 5.38% compound annual growth rate. This relationship is confirmed by the directly measured empirical trend, as shown in Graph 4 which exhibits a compound growth rate of 8%.



(*) Rates of data transmission for telephone, dial-up Internet, DSL, Broadband, etc. from <http://en.wikipedia.org/wiki/Bitrate>. For traditional media, bandwidth is calculated by calculating the number of bit equivalents of the information per second.

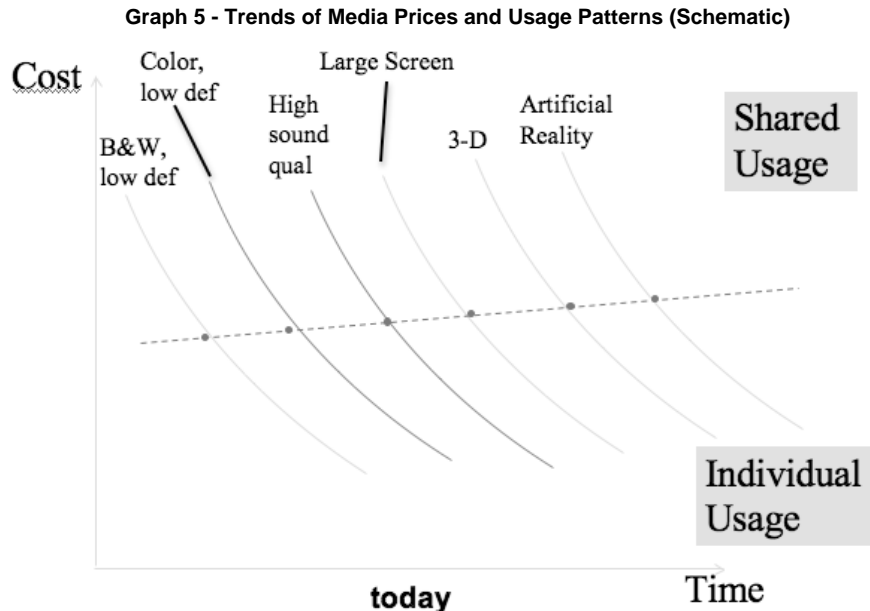
We can be more specific. Our data shows that the bit richness of print (books), once the dominant medium, was .00013 Mbit per second of consumption. Radio's bit rate was 0.096 Mbps. Standard analog television had about 2.5 Mbps. HDTV is 19.6 Mbps. The next generations of TV display, 2K and 4K , have compressed bitrate needs of about 180 Mbps and

640 Mbps, respectively. In each of these generations, visual imagery becomes more pronounced. In the print medium, a relatively few content bits are carefully crafted by the author, and the reader supplies the imagination process which enriches the experience. As the bit rate for a medium grows the visual imagery that is supplied by the medium rises. The growth rate of this enrichment, as measure above, is about 8% per year. In the process, the sensory content of a medium keeps rising. It becomes ever more realistic, approaching reality with its sounds and images.

■ Implication for content

What kind of television will such enrichment in terms of bits yield? There is no need to engage in futuristic imagining of the nature of content. Instead we can follow the trends of media in the past. And here one can observe the following path. The basic dynamics of a new medium are that when it is first introduced it tends to be relatively expensive; and in that period of high cost it is mainly consumed by elite users individually or in small groups. Soon the medium leads to the creation of a system of mass shared usage, which lowers the cost for each individual user, defrays the high fixed cost over multiple users, and enables the creation of high-cost productions of content. Examples include theater plays, public concerts, operas, all of which moved from high-priced individualized consumption to low-cost shared consumption through shared distribution technologies of large halls, film theaters, broadcast TV, and cable and satellite distribution. At this stage, consumption is by necessity synchronous, i.e., hundreds or even millions of users share the content simultaneously. But this is not the end of the story. In time, content and distribution costs decline still further and eventually move to a range that is affordable for regular individuals. Once this occurs, the medium starts to become individualized and asynchronous again.

Therefore, by looking at the present use of shared media, and assuming a certain rate of price decline per bit, we can predict the future of individualized media usage and its timing. It allows us to predict the next individual content type and medium by looking at existing shared communications styles.



The nature of a medium affects its content. When visual images could not be easily stored and transmitted, before film, the major medium was print. The print medium generated extraordinarily subtle works - novels, poems, all aimed at creating images in the imagination - using the compressed, bit-parsimonious technology of the written word. The human mind had to supply much of the processing and imagination. Film changed this. It explicitly filled in the visual details. Early film was probably the most unsubtle form of mass media expression ever. The less expensive bits are the more visual the medium becomes. The less expensive the visual aspects are the more they dominate. A weaker capacity for visuals favors story line, character development, and dialogue. With no sound, the early film medium relied primarily on action, painted in the broad strokes of slapstick comedy, simplistic plots, and uncomplicated characters. But still, the film medium could present visual tableaux that had not existed before and which quickly outperformed the visual capabilities of the acting stage. Thus, within the following ten years of the new medium of film new genres appeared in film, and new forms of expression were pioneered. The genres of science fiction (*A Trip to the Moon*, 1902), western adventure (*The Great Train Robbery*, 1903), and voyeur content (*The Gay Shoe Clerk*, 1905). Without sound, these were heavily visual and physical. The first feature length film with sound and embedded dialog came in 1927 with *The Jazz Singer*, and this advance soon enabled more subtle films with dialogue, ideas, and wit.

Two decades later, with the emergence of television with its black-and-white, low resolution visual content, theatrical film was prompted to upgrade its technology and content. Color and wide screen Cinemascope became standard. Sound improved enormously. Higher quality 70mm film was introduced, allowing filmmakers greater ability to include fast moving action, fine detail, close-ups, and convincing special effects. In content terms, theatrical films included themes of sex and violence, and provided spectacles with huge supporting casts and special effects. These films dominated worldwide. In contrast, Europeans had much lower budgets for advanced visuals, and so they shot black-and-white films with a greater portion of dialogue and character development, and much less in the way of action or special effects. Intellectually interesting, but visually flashy, such films were more like books on screen.

In the 1980s, computer animation began to emerge. In time, stars' faces were superimposed on others' bodies, and computer-generated characters were on the verge of substituting for human actors.

The combination of computer animation (especially in video games) and 3-D displays will create a new entertainment approaching total sensory captivation. This new entertainment would allow for user participation and some user control. Imagine dazzling computer generated special effects. Add virtual reality and game element. Imagine the avatars and participation in virtual worlds. A total immersion becomes possible, in which viewers become participants, inserting themselves with undivided attention into the action, in the center or on the sidelines, *Zelig*-like. This is where new content creators will go.

■ Implications for the content business

Now that we have a better idea of what ultra-broadband content will look like, the question is, who would supply it? To produce such content is expensive, and it will be scarce in its early phases. It requires creativity, many programmers, visual artists, special effects experience, performance testing, and constantly improved versions. This type of content exhibits strong economies of scale on the production side and network externalities on the demand side. Providers positioned to take best advantage of these factors are characterized by large budgets; ability to diversify risk and distribute over multiple platforms; strong branding; access to large

audiences; and an ability to coordinate specialized inputs. Premium content then will be supplied by large and complex providers. Long tail content, on the other hand, can be readily produced by just about anyone with a broadband connection. This means that there will rarely be sustained profit in it. There will be room for experimental developers for such content, and should it prove successful these suppliers will likely be acquired by the larger players. Other content is likely to be developed through interactive communities of individual non-commercial developers, or through a multiplicity of small specialist commercial firms coordinated by large integrators.

Hollywood studios already spend heavily on premium content. For *Terminator 3* (2003), \$20 million were spent on computer generated special effects alone. In the same year, the *Attack of the Clones* listed 572 technicians (EPSTEIN, 2005). Premium ultrabroadband content is likely to be still more expensive. Is there really a demand to justify it? The answer would appear to be yes, given the ever-rising levels of stimulation that media consumers seem to require. In terms of global demand, if 100 million households use such content for 2 hours per week at \$5, the annual revenue generated is \$52 billion, with maybe half each going to distribution and to content.

The globalization of media will also be affected. Contributing elements are 1) the price of international transmission is dropping rapidly, 2) internet penetrations are increasing rapidly, and 3) ultrabroadband content has economies of scale. U.S. firms are likely to play a major role in such content. They are early entrants, with large domestic audiences, leading software and hardware suppliers, access to risk capital, global talent, and established distribution channels

■ Conclusions

To summarize, we find that:

- Individualizations of content style (of space and time; of consumption mode; or of source) do not require ultra-broadband on the user level.
- Transmission capacity must match requirements of content richness. If the content requires 5 Mbps, there is no need for pipes with much higher capacity.

- Storage and transmission are substitutes for one another. In fact, as storage becomes less expensive, it requires less transmission than in the past. One needs only one or two channels of access to video servers. For regular quality TV, to enable more content diversity, the proper approach would be to store more programs and make access and download possible. Synchronous channels make sense only for large audiences or live-critical content - such as sports events.

- The price people have been willing to pay for media entertainment per time unit has been fairly steady over a century, adjusted for inflation, at about 4.4 cents per minute.

- The price of distribution of content has been dropping at a compound rate of 8%.

- Vertically, the bit quantity of media content has risen at a steady clip, at the rate of about 8% per year.

- This enrichment of media content leads to genres and styles that are individualized, immersive, and often interactive.

- For the first time, entertainment at home will be technically superior to that in a shared communal environment.

- It is only a matter of time, given the trends of steady enrichment of media content in terms of signals, that media content will be richer in sensory terms than real life.

Thus, should technology continue to influence content as it has, we can look forward to ultra-broadband content that is highly individualized, customizable, and of unprecedented sensory richness. Ultra-broadband pipes will require appropriate ultra-content in order to be economically viable. Yet to realize these new content forms and genres will take time and creativity, trial and error. The implication for the infrastructure providers is that to fill their pipes with users, they must begin helping to explore and develop ultra-broadband content. If they do not support new content creation, and if they restrict access, they will find that they have created a ballroom with nobody ready to dance. This interaction of new generation infrastructure networks with new generation content leaves much room for business initiative, technological innovation, and creators' originality. And it provides media researchers with important new topics of study on the nature of culture, entertainment, games, and news in the next electronic environment.