

# Ultrabroadband Networks: an Introduction to Research

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Since the dawning of internet telecommunications in the 1970s, higher transmission rates for more advanced applications have been a major objective. Current broadband data speeds are over a thousand times as fast as early dial-up narrowband internet services, and ultrabroadband (1 Gigabit per second or more) will be another thousand-fold increase. Ultrabroadband will also be more bi-directional in media applications, allowing users to also become information providers. The technical complexities are large. On the business level, these developments require substantial investment in the access, backhaul, and wireless segments, create new risks (and rewards) and lead to enormous new competitive overlaps. On the applications and content dimension, entirely new uses and genres become possible. And on the network level, the increased utilization levels will put new demands on communications infrastructure.

With fiber penetration moving rapidly ahead, one must think ahead. There are numerous questions for analysis and research. In no particular order:

- What are the different ultrabroadband deployment plans across the industrialized and developing world?
- What is the impact on content?
- What are the determining factors for business strategies, pricing models, applications, advertising opportunities?
- What are the regulatory scenarios? How are traditional arrangements affected?
- Should there be national ultrabroadband policies?

- What are the impacts on broadband market structure? On competition?
  - What are the new quality of services dimensions?
  - What would one do with a gigabit per second?
  - How does one estimate demand?
  - What are the pricing models?
  - What are the network architecture options?
  - What is the role of wireless?
  - What are the major standards issues?
  - Will there be a need to redesign and reengineer the internet structure?
  - What kind of new-generation home networks are emerging?
  - Is UBB a natural ultra-monopoly?
  - What are the options and tools for ultrabroadband policies?
  - What kind of economics and culture will evolve for user generated content?
- What will be the impact on tele-working and transportation?

Ultrabroadband moves us to the next generation of telecommunications. It is helpful to think in terms of three generations of telecom. "Telecom 1.0" was the traditional monopoly system, state owned or tightly regulated. Technologically it was based on copper analog networks. Culturally it was shaped by an engineering and state bureaucracy. This arrangement lasted for a century. After the 1980s it was transformed into a more open system, with liberalized new entrants, privatized incumbents, and accelerating innovation. In hindsight, one can observe that this "Telecom 2.0" was triggered by wireless technology (though it soon went beyond it). The entire concept of network competition emerged in America from microwave alternatives (based on technology pioneered in World War II) to the incumbent long distance network. On the mobile side, wireless cellular technology introduced the concept of private and competitive communications around the world. Technology was the enabler. Economists, lawyers, and IT entrepreneurs changed the way people and governments thought about communications. Soon, the internet took off, first by slow-speed narrowband and then with faster broadband.

But this was not the end of history. Technology took another major step forward, this time focused around fiber optic access networks. Fiber had been around for decades. But only in the 2000s did it reach or approach residential homes. This trend is still in its beginnings, and it leads us to Telecom 3.0.

In recent years, corporate strategy and public policy have been based on the Telecom 2.0 framework. Policy may aim to be technology-neutral, but if the underlying technology changes, telecom economics and policy will inevitably change, too. The policy goals may remain with ultrabroadband but the approaches to achieve them will differ.

Developments paths have diverged. North America, Korea, and several of the cable-rich European countries of Benelux, Scandinavia, or Switzerland are moving to what can be called a "2.5 platform" infrastructure, with the number signifying the presence of two major platforms, primarily telcom-fiber and cable television fiber-coax hybrid, as well as smaller platforms such as satellite and terrestrial wireless. In contrast, other European countries seem to be moving mostly to a platform system, centered on the copper/DSL phone infrastructure, which will eventually be upgraded to fiber, plus smaller medium-speed wireless options. This is simplifying, of course. Each country is likely to have more competitive regions, depending on population density. And wireless technology might create options of speed sufficient to be satisfactory to many people.

Possibly, the capacity of fiber and its economies of scale are so high as to permit only one such infrastructure, or the creation of a shared infrastructure for both or more partners. The sharing arrangement - "mutualization" - indicates a situation where multiple parallel infrastructures are not feasible or efficient economically in terms of cost and risk exposure. In other cases, not even one network is sustainable in most parts of a region, and such a system might be termed "0.5".

What has been the reality of ultrabroadband-capable residential access networks? As of June 2008, Japan (12 mil, of which 9 mil are by NTT) and South Korea (6 mil) are leading in terms of FTTH subscriber count. In the US, there were 3.5 million subscribers, of which about 2 million were by Verizon. That company was in the midst of implementing a \$23 bil FTTH upgrade plan (€17,4bil). Its offered speed for FTTH service rose to 175Mbps. US telecom companies have been realizing that it would not be possible to survive competition against cable with only DSL in the broadband market.

In Europe, the majority of Europe's fiber access still lies in the Scandinavian region, but other nations are moving forward, both in plans and actuality. In July 2008, BT announced its plan to invest £1.5 billion (about €1.9 billion/ \$2,45 billion) over the years 2008-2012 in fiber to the street cabinet (FTTC). The Olympic village and other select locations will have the fiber connected directly to the premises, but those look to be less than 10% of the installs, BT said. Nevertheless, after having rejected FTTH investments in 2006, BT decision reflects faster than expected growth in market demand for high capacity applications such as IPTV. It's also BT's response to its competitors (Virgin Media, Carephone Warehouse and BSkyB), switching their clients to their own broadband network and no longer renting copper lines from BT. BT also said it would discuss with Ofcom "removing current barriers to investment" and making sure that investments in fiber optic earn a "fair rate of return" for shareholders. After consultation with industry, Ofcom said in September 2008, it would publish a statement on super-fast broadband in spring 2009.

France's industry ministry set a goal of 4 million FTTH deployments by 2012. France Telecom is investing an initial €270 million (\$360 million) through the end of 2008. Iliad has committed €1 billion (\$1.32 billion) through 2012, and SFR will spend €450 million (\$595 million) through 2010 specific to in and around Paris.

In general, the most immediate obstacle to FTTH investment is the regulatory environment. EC seems to support an expansion of the access regime of metallic circuits to fiber optic ones while some of the national regulators do the reverse. In Japan, NTT is in uncertainty in its previously declared FTTH plans due to LLU regulation.

Besides the LLU issue, a favorable policy framework for network advancement would be to facilitate increased investment and continued technological development.

In Korea, the government is organizing a consortium of broadcasting and communications operators for upgrading the current infrastructure to BcN (Broadband Convergence Network) providing 50~100Mbps of subscriber capacity. By the end of 2008, it will introduce the "Giga internet" test service that will enable large capacity services including 3D video conferencing.

As in many issues of economic policy, there are two fundamental societal goals: growth and openness. The latter includes ability to participate and to compete. In societies based on democracy and a market system, the two

reinforce each other. While growth and openness can at times be also in friction with each other, they are basically mutually reinforcing. For example, the flowering of peer-to-peer video, in which millions of people share video creations of entertainment and opinion, could not have happened without the buildup of a high-speed telecom infrastructure, which required major investments. (Today, according to some measurements, 43% of all internet traffic and 75% of all upstream traffic is P2P). In the process, enormous creativity, social and political interaction, and commercial opportunities are being generated for all. For the network operators there is a huge increase in traffic, and since they are in the bit-transport business, this should be, in principle, good news. Of course, this expanding traffic must also be reflected not just in volume but in revenues. And it may create some capacity bottlenecks. But one should focus on the big picture: demand is growing explosively in terms of bits and minutes of use.

This special volume will explore financial, regulatory, international, content and technological dimensions of the next generation of broadband - "ultrabroadband" - and the vast changes in mass media, consumer electronics, and information systems that it will drive.

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The project brought together policy makers, industry experts, and academics from the United States, Korea and Europe. It was initiated by the Columbia Institute for Tele-Information (CITI) as a joint project with the Chair on Innovation and Regulation in the Digital Economy (Ecole Polytechnique - Telecom ParisTech - OrangeLabs), Korea Telecom, and Telecom Italia. Several conferences, in New York, Paris, and Seoul, were milestones along the way. Contributors brought their own perspectives, which at times may be those of their employers; but the project as a whole was not managed with any perspective except that of bringing together advanced academic and industry thinking.

Eli NOAM, in his article "If Fiber is the Medium, What is the Message?" asks the questions: What would super-broadband connectivity be used for? He focuses on entertainment content as critical for the economic viability of an ultrabroadband infrastructure. To predict content usage, he models the willingness to pay for entertainment for 25 media over the past century as composed of two elements: the content cost, and the distribution cost. He finds that the price people have been willing to pay for media entertainment per time unit has been fairly steady for over a century, after inflation. The model and the empirical estimations, lead him to conclude that the

"information-richness" of media consumption in terms of bits per second has been growing at about 8% per annum. Projecting this rate permits us to predict the type, style, and genres of media content of the near future. These types of media will be highly visual, immersive and often individualized, with a significant involvement component. The model also enables us to determine the time when media will become visually richer than 3-D real life in terms of sensory experience.

Regulation and competition have a strong impact in the UBB market formation. Robert ATKINSON in his article "Market structure for Ultrabroadband markets" asks the question "Should We Expect Multiple, Competitive UBB Access Infrastructures or Regulated Monopoly Utilities? or Something Else?" He concluded that there will not be a single, universal UBB system but market structures ranging from competition to duopoly and monopoly, including heavily subsidized systems. This will be primarily a function of the number of UBB infrastructures that a particular market can sustain. As the circumstances of each market change, market structures will also evolve.

If changes in these market structures accompany major technical evolutions, then the macroeconomic impacts of such infrastructure deployment and services development have to be considered. Jean-Sébastien BEDO, Stéphane CIRIANI, Fabrice COLLARD, Patrick FEVE & Franck PORTIER build and estimate a dynamic equilibrium model of the technological transition when one adopts a highly capital intensive technology such as a new generation telecommunication network. They demonstrate that the endogenous adoption of such a technology can lead to cross-sector relocation of resources, and that such a technological change does not harm employment in the medium and the long run, and is welfare improving.

When discussing a new technology, one of the most important factors is to explore its diffusion and deployment. Anastassios GENTZOGLANIS & Elias ARAVANTINOS in their article "Forecast Models of Broadband Diffusion and Other Information Technologies" review the broadband diffusion literature of the kind that is useful for economists, business analysts, and policy makers. These diffusion models proved to be robust and could be also used for the UBB technology.

However, a robust forecasting model is not enough when there is no investment planning, especially for the right technology. Will a stand-alone investment for fiber yield positive returns? Raul KATZ, in his article

"Ultrabroadband investment models" believes that, so far, the answer is no. Three factors are affecting the overall case: the CAPEX problem (fiber builds tend to reduce free cash flows by 20-30%), demand for new services remains speculative so far, and consumers balk at seeing prices for enhancing throughput rise. His study indicates that, beyond the commercial and strategic moves attempted by carriers like Verizon, it would appear that there is some benefit to looking at fiber networks as two-sided markets with the consequent ability to monetize the investment. This would be done through advertising and other platform-based strategies, where UBB networks are positioned as a facilitator of transactions (such as advertising, financial, support of user generated content) with the ability to generate access revenues, advertising fees, financial commissions and the like. In addition, KATZ's analysis concludes that the regulatory and industrial policy variable is the only one that can provide some flexibility. This would require in Europe to review wholesale access obligations for fiber. Alternatively, governments (like the Asian examples) should consider fiber to be a new highway system and therefore subject it to massive government investment.

UBB features new technology, new market structure, new regulation, but also new competitive models. Horizontal and vertical relations between all industry players are affected. Telecom operators either fixed or mobile, cable operators, internet providers are all considering "multiplay" strategies. Antonin ARLANDIS models this new form of competition, based on bundling and economies of scope. He reaches conclusions on the impact on firms' profits, consumer surplus and welfare depending on partial or complete coverage of the market: the economies of scope created by mix bundling reduce firm profits when the market is completely covered and increase it when the market is partially covered. Economies of scope, also, always tend to increase consumer surplus and to lower welfare when the market is completely covered whereas increase welfare when the market is partially covered.

When analyzing UBB and a new technology, we should also try to think of the competitive and regulatory trends that will have an impact in the diffusion path. Armando CALABRESE, Massimo GASTALDI, Irene IACOVELLI & Nathan LEVIALDI GHIRON, in their paper "Ultrabroadband competition in two-sided markets" study the competition in two-sided market between communication and telecommunication platforms on their pricing strategies. They run numerical simulations on different scenarios whose data has been tested by interviews with experts of such industries. They find a relation between the benefits provided by ultrabroadband convergence (triple

play) and the pricing structures. In the case of benefits homogeneity on both sides, the pricing structure is composed of identical prices on both sides. In the case of benefits heterogeneity between the two sides of the market, the pricing structure is composed of higher prices on the market side characterized by higher benefit levels.

One could have another and complementary view from a two sided market perspective. Assuming that Ultrabroadband "would be a truly revolutionary value-creating medium", Beong-geel CHOI explores infrastructure firm strategies in that perspective, through a model aimed at better understanding and developing strategies for ISP serving general subscribers on the one side and content providers on the other side.

On such infrastructure, as web 2.0 services experienced it, advertising might be the main source of revenues for services providers, despite the fact that these revenues are not yet in line with the audience of the offered services. Jean-Samuel BEUSCART & Kevin MELLET, examine the business model of web 2.0 services in order to draw some perspective for the development of these revenues in the UBB era.

UBB promises to provide new services to the consumers, involving and immersing them. But there are techno-economic roadblocks. For example, the evolution of available bandwidth is not synchronized between home networks, access networks, and backhaul networks. It will cause problems in quality control, with congestion points evolving in the network. In addition, the interoperability between all the different services and devices is not assured. There is a lack of standards in middleware in the home networking area. Martial BELLEC, Marie-Hélène HAMON, Arnaud JOLY, Sandrine LAMOTTE, Sylvain MEYER & Vincent OLIVE, explore this issue: How will UBB services penetrate all home terminal equipments? They identified severe bottlenecks that still need to be popped-off before the 'connected home' become a reality.

In such a "connected home", the user is not aware of the devices and the infrastructure network. This will be another potential success constraint of the UBB : the right collaboration between Quality of Service (QoS) and the Quality of Experience (QoE) over the last mile meeting consumer's expectations. Elias ARAVANTINOS & John PAPAGIANNOPOULOS, in their article "QoS in Ultrabroadband models" are raising the question whether QoS concerns and activities are still relevant in the abundance in UBB, and what the role of the user would be. They concluded that QoS will still play a significant role. Models for multiplayer services could get very complicated and

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UBB could only simplify specific and few processes that are related to throughput and bandwidth. The QoE from a user's perspective will assure the ultimate experience but also help constructing cost models, especially when users' needs shift beyond their pre-agreed levels with the operators.

All articles in this volume explore a facet of the UBB perspective. It is a contribution to the understanding of the emerging environment. In particular, how should management and governments need to think about this emerging environment? Not just as 'more of the same'. And neither should researchers. This was the premise of the volume before you.