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Mid-term forecasting of electronic communication markets development in Croatia

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"Mid-term forecasting of electronic communication markets development in Croatia"
Letter of Contract N. 2006– 0707-0315

Report E and F
on forecast of key trends in Croatian Market in mid term and key market opportunities

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LOT 3: Telecommunications and Information technologies

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1 Objectives of the project

The global objective of the project is to assure further strengthening of regulatory rules of the telecommunications market in Croatia (in compliance with the EU *acquis*), which will contribute to its further development.

In the Terms of reference there are two specific objectives mentioned:

To provide an overview of the entire telecommunications market in Croatia including both historical data and future projections in order to provide access to the information necessary for focusing research and development efforts and developing new products and business strategies.

To provide strategic assessment of the role of regulatory rules (laws, bylaws, decisions) in the telecommunications sector with the main focus on the role of competition in delivering benefits for customers.

Emphasis on broadband
In discussions with the beneficiary it was asked and agreed that the project would put emphasis on the broadband development as this is of vital importance to the development of the information society in Croatia.

2 Introduction

Using the data as collected in the studies of the project group, some trends are presented in this report. It must however be noted that the present economic developments have made any prediction quite uncertain (Deliverable E).

This report also includes an economic study on different scenarios for the future and key market opportunities in terms of investment and innovative technologies in the Croatian Telecommunications market. A comparison will be given on the different technologies available for broadband development and their possibilities for deployment in terms of investment (Deliverable F).

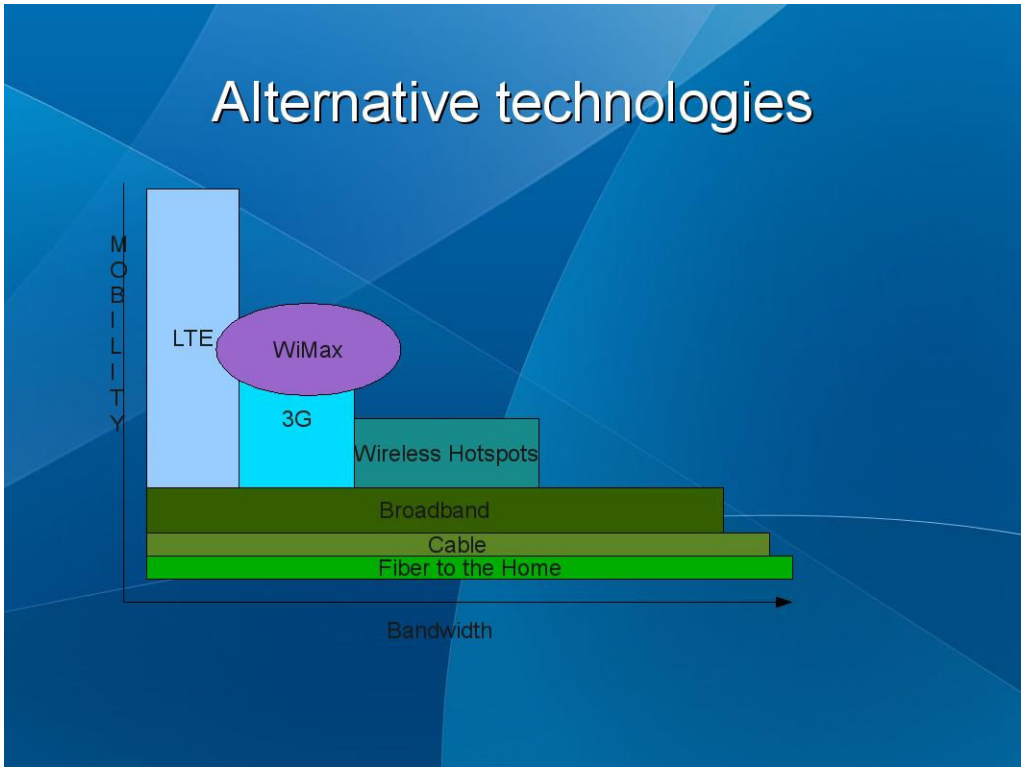
In order to put the different scenarios into perspective we also give a description of the most important technologies that are used in telecommunications with some extra emphasis on Internet as in the near future the telecommunications and Internet will slowly merge into one overall system.

3 Scenario's for the future, key market opportunities in terms of investment and innovative technologies and forecast on key trends in the Croatian Telecommunications sector

A comparison will be given on the different technologies available for broadband development and their possibilities for deployment in terms of investment. Some trends will also be presented. It must however be noted that the present economic developments make any prediction quite uncertain.

3.1 Broadband alternative technologies

Below is a graphical view of the alternative technologies predicted in the mid-term. The different technologies are divided by mobility and bandwidth. Their relative sizes are very generally related to estimates of uptake.



3.2 Investment

The telecom industry is an industry that has high investment costs. This makes market entry extremely difficult and financially demanding because generally it requires a certain minimum scale. On the other hand, those players that have established themselves in any given market generally have a stable business opportunity. Below, Investment is analysed from the perspective of the different market players.

3.3 Opportunities

Market player opportunities and threats will be outlined where applicable.

3.3.1 Incumbent

The Incumbent, Croatia Telecom (HT) a subsidiary of Deutsche Telecom (T-Com) has the needed capital for Telecom investment. It actually has been investing in Croatia at a steady rate but major upgrades to the existing network have been waiting for the market situation to stabilize and for the regulator (HAKOM) to pre-define market conditions for the long term.

Pilot studies have been conducted by HT for the future and probably role-out of FttH.

Major investment decisions are financially very demanding and need levels of stability and predictability that so far have not existed in the Croatian market. HT is nervous in such an unpredictable business environment. Long term investments into e.g. FttH require stability and predictability especially from the regulator.

In summary, the Incumbent meets all the requirements for being the most probable entity to invest in the Croatian Telecom industry. The challenge for the regulator is to encourage HT to invest without allowing it to make monopolistic profits.

3.3.2 The Alternative operators:

The alternative operators do not have the capital for major infrastructure investments. Based on their financial data, especially liquidity analysis, they have three options for major investment paths that are not mutually exclusive:

A) they need a big brother from one of the large international telecom players
B) they need to build up operating capital through operating within the HT network.
C) they need to consolidate resources through mergers of acquisitions or at the very least get cooperative agreements to gain economies of scale.

The first option is extremely interesting for the alternative operators who are already very short of cash, but the current world economic downturn makes finding interested parties or available investment capital difficult to come by. This poses an immediate threat for the alternative operators.

The second option is a long-term solution that requires a steady healthy development environment for the alternative operators. This is called the investment ladder. Ideally the operators start as operator using the infrastructure of others but gradually implements its own infrastructure wherever possible. The regulator must stimulate this. Key factors for this to happen include stability, predictability and access by the regulator. This would require careful and successful regulation of both bitstream and ULL by the regulator.

Setting pricing at a level that ensures the incumbent financially fair returns for its investment but also ensuring a competitive environment for the alternative operators is simple to define as the task of the regulator, but in practice requires skill and experience to achieve.

To ensure a competitive environment, Optical networks need some successful conditions for their implementation. This can be achieved either though separate regulation of optical networks or by making regulation technology-independent.

3.4 Innovative technologies

With the overwhelming market share of the incumbent in the broadband market in Croatia, the new entrants are having a very difficult time competing directly. Often in such cases, there still exist opportunities for competition. If direct competition looks uncompetitive, indirect competition might offer better economic returns.

3.5 Broadband and Direct Competition

Offering broadband in direct competition against the incumbent holding a market share of over 90% is difficult. The specific market conditions in Croatia expressed above make market entry into this market very difficult. Economies of scale, experience in the telecom market and actual control of the copper infrastructure allow HT to largely control the market.

That said, the broadband usage will continue to grow in Croatia. Currently broadband is in use in around 33% of the homes. The leading countries in Europe show that levels of over 70% can be expected. So there still is room in the market for growth.

3.5.1 Competition in the Broadband market

The situation is as follows:

- HT dominates the market
- HT owns the infrastructure
- Alternate operators lack business strategy
- Alternate operators lack powerful international back-offices
- Alternate operators are low on cash
- HT discriminates with line installation, repair & outages?

Looking at the mid-term, the incumbent HT appear to be “milking the cow” in its strategic focus of broadband. There is some level of investment but nothing that can be considered as large-scale infrastructure investing. Considering its dominant market share, this is unlikely to change in the mid-term.

The other players do not have the resources to compete head on with the market leader. This is unlikely to change without noticeable regulatory moves, especially in the LLU pricing, to give the alternate operators a more equal battle ground. That said, it is slightly worrisome due to the situation where the alternate operators are short of capital and may even be lacking management skills to compete against HT.

3.5.2 ADSL will develop further

On the short to medium term ADSL technology is liley to remain the dominant technology, both used by HT and by its competitors. The present household penetration of broadband of 33% is likely to grow, even though the economic downturn might slow down the speed of its advance. A realistic perspective for Croatia in the next two or three years is a growth to a household penetration of ADSL to 50% which means to about 700.000 households with a broadband ADSL line. After this period mobile broadband may take over part of the further growth, partially replacing fixed ADSL and FttH is well positioned for introduction on wider scale after three or four year, provided the regulatory conditions are well prepared for this. There are limits to the growth of ADSL because of technical reasons in the sense that only a limited number of telephone subscribers can use it as not all cable pairs in feeder cables can be used. A specific problem in Croatia is that in Zagreb and Split there may not be enough room in ducts to lay extra cables.

3.5.3 Is indirect competition the answer?

In the Croatian market, where there is a very strong dominant incumbent that holds over 90% of the broadband market, competition theory supports the basic concept of indirect competition for these scenarios. With this in mind, several alternate technologies are looked at below with an attempt to analyse how they might serve as an alternate approach to increasing the competitiveness of the Croatian broadband market.

3.5.4 Indirect Competition scenarios:

3.5.4.1 Copper Bitstream markets:

Companies that do not have the financial resources to invest into LLU should take a careful look at the option of piggy-back riding on the HT network. If the regulation (=price) is set correctly by the regulator, there are opportunities for competition even for "small" companies against the incumbent by focusing on sectoral, regional and/or other strata.

New entrants into the market have the opportunity to enter the market with a bitstream push. As such, any increased competition should be welcomed, be it even at a smaller scale. If the

regulatory function is on par, they should have the opportunity to establish themselves and expand. Mid-term, these entrants most probably can not be considered to be major players in the market. A large percentage of start-ups fail relatively quickly but still, every now and then, one of them will push through into the major league.

3.5.4.2 Fibre To The Home (FttH)

One alternative scenario for the Croatian market that really has to be looked at carefully is FttH. After a realistic look at the current situation, one could accept that HT has to a large extent eaten up the broadband market and look to the future and what is perceived by many as the next generation of fixed communications after copper; that is Fibre to the Home. In this scenario, which does not exclude other scenarios described in this document, but compliment many of them, the objective of the regulator could be to formulate a strategy for FttH with the objective of creating a new regulated market based on optical networks that takes on board lessons learnt with copper and provides a platform for fair competition in this emerging technology.

3.5.4.2.1 Suggested key factors and competitive environment that can be used as the base for "Getting FttH to the Croatian Consumer"

Fibre infrastructure is a long term investment. Any operator considering the undertaking of such a huge investment has to feel confident of anticipated returns.

Key issues for making such investments are:

- Long Term stability. This should be considered as one prerequisite.
- Pre-defined intervention policy's. There should be a clear understanding of how the regulator will use its powers (for unbundled access) to control the competitiveness of the market. It would be ideal if they were presented with the actual tariffs and how these will develop in advance.
- Predictability. It is understandable that confidence in the regulatory body is a huge boost for the propensity to invest, even more so for the large investments that are needed for FttH.
- Cooperative regulatory environment. Asymmetric regulatory intervention builds distrust and has a direct correlation with investment willingness

From the perspective of regulation and competition, preference should be given to Unbundled Fibre Access over Wholesale Broadband Access (WBA).

All too often, regulators have done the right thing and regulated over-profitable incumbents. However few have had a mechanism in place to adjust regulation when the investments have not succeeded, claiming the risk burden is part of the operators business.

In essence, it is not an easy task to create an access price that makes the business case for access seekers attractive and feasible, while creating competition at the retail level as well as at the wholesale (WBA) level. The regulator still needs to aim to create an access price (and price structure) that is acceptable by the FttH investors while leaving space for an optimistic business scenario in the business case.

3.5.4.2.2 The Dutch example:

Of course, the Dutch scenario, environment and competitive environment is not totally equivalent to the situation in Croatia. Despite the existing differences, some important lessons can be learnt and a way forward can be mapped that uses their experience and is still adjusted to the local situation.

3.5.4.2.3 Results in the Dutch Experience:

Below are outlined the key results of the Dutch experience.

- Market definition. The market needs to be clearly defined

- Access. The market is open to new entrants
- Transparency. Regulation is done with consultation and openness
- Non-discrimination. All players are treated equally
- Cost orientation. Regulatory pricing is built on replacement costs and a modified form of Long Range Incremental Costing (LRIC)
- Different price per area. Cable investment costs vary by area (are not constant)
- Post-installation Capital Expenditure (CAPEX) classification (after the installation costs were known) (NL: 5 different classes. HR probably needs more classes and a wider distribution)

The Dutch model had an interesting concept of how to set regulatory prices for FttH.

The cost of optical trenching in the Netherlands is 13€/m, and for copper 8€/m. Almost 100% of this is the digging/trenching costs.

The Dutch regulator (OPTA) agreed to an upfront payment per line: 80€ (start-up fee) to advance investment returns directly even though this should not be considered as cost-related costs. The reasoning for this was that it directly reduces investment capital and is up-front returns.

Volume discount (up to 20%) were included as part of pricing structure.
Indexation of wholesale prices with Consumer Price Index (CPI)

Inflation correction using simply CPI (it is debatable whether this is needed)

And a periodic check on excessive returns. Every three years checks on the returns at that time. An "excessive return" leads to downwards adjustment of the price cap.

Situation of over-performance. "excessive return" had to be pre-defined and was documented as a return that is higher then the optimistic scenario in the actual business case for the investment project. In the case of FttH, this is calculated for a penetration expectation of 80% (Base case + 20%), with all other parameters unchanged (including the prices). The outcome of this calculation is a delta (difference between the optimistic and the base scenario) of 3.5% (in the IRR). With each periodic check, the 3.5% is used in the comparison of the actual Internal rate of Return (IRR) against the normative Weighted Average Cost of Capital (WACC) for the FttH

It is very important to look at these factors in a sparsely populated country with large geographic areas, variances in income levels, population densities, demographics and geography. The Dutch example is noticeably easier due to a high population density, a small country which is mostly flat and fertile and noticeably more uniform wealth distribution country-wide.

This summary only aims to give a very broad overview of the Dutch solution, outlining key factors and pointing out key deciding factors they had to face and solve in achieving a regulatory solution for FttH in Holland. These lessons leant can be very useful for formulating regulatory solutions for FttH in other countries as well. That said, no two markets are identical and sometimes, what applies to one country is not applicable in any other country so they have to be taken with some reserves.

3.5.4.2.4 FttH in Croatia

The deployment of FttH has already started in Croatia. Mainly these have been pilot projects by several operators, including the incumbent. In addition, municipalities /cities have started building or are planning to build infrastructure in Croatia. The Director of HT has even gone public with plans by HT to have 5000 FttH clients by the end of 2009. It remains to be seen how realistic these plans are or whether they are strategic moves by HT in their business case to remain the dominant operator in Croatia in this sector as well.

This technology is a high investment undertaking. The most likely operator to take on any large scale infrastructure developments in Croatia is most likely HT. In all likelihood, fibre will be the next development in fixed line communications in Croatia as in other countries as well.

A specific point: Gigabit Passive Optical Network (GPON) is the dominant technical solution for Fibre in Croatia. The way HT chose to implement this technology is such that alternative operators cannot simply use a separate fibre to deliver their services to end users but have to use the basic signals of HT. All the signals to several end users are transmitted on one

fibre and therefore physical splitting up is not obvious. This can be compared to bitstream access in the ADSL environment.
The layout of the network should ideally be such that unbundling and free competition remain possible without much extra investment in comparison to straightforward Point-to-Point (P2P) Optical. This is the dominant solution in other countries like in e.g. The Netherlands. It is recommended that the regulator should work at favouring solutions that do not right from the start limit competition in this emerging technology.

With future role-out of FttH, from the regulators perspective, important considerations are how to find an operator that is willing to undertake the needed investments, how to ensure that it can have due returns for the investments yet balance these investment incentives with regulations that ensure a competitive environment for the market and does not close competition by the alternate operators. If it is any consolidation, regulators throughout Europe and beyond face the same issue and so far no one solution has gained universal acceptance.

FttH is a viable indirect competitor to broadband and a viable opportunity for increasing broadband usage in Croatia. It is also the most likely successor. If the eventual goal of the regulator is to increase competition with the goal of decreasing costs to the consumer for high-speed Internet, regulation has to succeed to provide a competitive environment, or else the experience of a monopoly on copper will be repeated in Croatia.

There is also at least one identified player that is interested in investing in the technology, but the process of coming to a common agreement on the terms and conditions of such an agreement are still a long way ahead and unless a structured path is planned, FttH might and probably will develop ad-hoc and uncontrolled. This would not be the optimal development path forwards.

3.5.4.3 Mobile Broadband

The competitive situation in the mobile market is looking extremely promising and new technologies such as Long Term Evolution (LTE) can offer indirect completion to classic broadband. While broadband operators favour the prediction that mobile broadband will remain a marginal technology, used by only a few people on the move but not replacing broadband to the home, consumers will be the deciding parties when they consider their needs and budget of connectivity.

There already is some evidence of mobile broadband market share growing in certain developed markets. Just as mobile phones have eaten away at the wired telephony services earlier, many predict that a similar trend is becoming visible with the ratio of broadband to wireless broadband. Extremely aggressive pricing and anticipated vast improvements in data transfer rates for mobile broadband both are pushing this market segment into strong growth.

Finnish example
In Finland current pricing 10€/month unlimited use capped at 0.384Mb/s and 19.90€/month unlimited at 2Mb/s for mobile Internet have proved very interesting for the consumers, who are normally offered unlimited broadband capped at 1mb/s for 24€/month and 32€/month unlimited broadband capped at 2Mb/s. These figures show that mobile broadband at comparable speeds is actually less expensive than broadband. In addition the operators are investing heavily in updating their networks to support the new and future LTE technologies, promising a even brighter

"The adoption of Mobile Broadband looks set to increase in spite of the economic slowdown. Mobile broadband adoption will continue to grow relentlessly across Europe, boosted by the introduction of improved UMTS (3G+) and 4G (LTE and/or WiMAX), expanding device selection and usability, and the gains mobile networks are making in affordability and pricing, according to a new report from Pyramid Research. Thanks to the right conditions existing in Europe -including the wide availability and high quality of mobile broadband, attractive pricing, and user-friendly devices- the number of European mobile broadband users will reach 116.6 million in 2014, up from 24.3 million in 2008. Surging demand for Internet mobility is driving deployments and upgrades of

broadband-capable mobile networks. With operators announcing 3G, 3G+, and LTE rollouts, spending on networks upgrades is expected to be stable in spite of the economic slowdown. Mobile broadband devices are ready for the mass market. As a full-blown, mass-market push for mobile broadband drives down prices, mobile broadband is becoming competitive against basic fixed broadband across Europe. Also, the recent emergence of prepaid mobile broadband offers is likely to attract business users who travel or commute a lot, as well as others who value mobility. In lower-income markets, prepaid plans open the door to mobile broadband for those who do not have access to broadband-capable fixed infrastructure and cannot commit to lengthy postpaid mobile broadband contracts.[1]"

3.5.4.4 Mobile Broadband Trends

Currently 3G technology is the most prominent in the local market. Of the three mobile operators, VIPnet is the most advanced mobile broadband operator in Croatia. The newest mobile operator, Tele2, will be competitive technology-wise as it has been steadily expanding its network coverage with new modern equipment. By their own admission, they have kept a low profile with mobile broadband due to the fact that they are still tied to the incumbent with roaming agreements until their network infrastructure coverage plans are completed.

The incumbent, T-Mobile, has the oldest national network. Their low levels of investment in new technologies might be perceived as a strategy of "cash-cowing" and the knowing decision to wait for the emerging LTE technologies, skipping the UTMS phase altogether. This actually gives the market newcomers a competitive advantage to increase market shares if they use this window of opportunity. After discussions with Tele2 and taking into account the strong presence of VIPNet already in this segment, it is highly probable that there will be strong competition for this growing market segment.

Strong competition for market shares, an international growth of awareness for this emerging technology and the promising news of emerging new technologies (LTE) that should offer a relatively easily and cost-effectively upgrade path from current UTMS base stations all indicate that:

- This option should be perceived as a viable indirect competition alternative for the Croatian broadband market.
- The high level of competition between the mobile operators should filter through to the mobile broadband market, resulting in competitive pricing.
- Once the price of mobile broadband in the Croatian market reach levels already visible in more developed mobile markets, mobile broadband should become perceived by the consumer as an alternative solution to broadband.
- Mobile broadband has the added benefit of mobility.

The absence of a nationwide cable operator that can offer high speed Internet access through the usage of the Docsis.3 technology increases the chances for mobile broadband.

3.5.4.5 Long Term Evolution (LTE):

The mobile broadband market is buzzing with the finalisation of the LTE standards, which many current 3G operators perceive as the evolution of 3G technology. Many of the large suppliers and operators have committed to LTE as their strategic focus. There are several points listed below that go to show that belief in this emerging technology should be strong:

- LTE offers much faster data throughput then 3G
    - LTE provides downlink peak rates of at least 100Mbit/s, 50 Mbit/s in the uplink and RAN (Radio Access Network) round-trip times of less than 10ms.
    - 3G: HSPA data rates up to 14.4 Mbit/s on the downlink and 5.8 Mbit/s on the uplink.

[1] Source: Cellular News

  - 2.5G: EDGE data speeds up to 236.8 kbit/s (with end-to-end latency of less than 150 ms) for 4 timeslots (theoretical maximum is 473.6 kbit/s for 8 timeslots) in packet mode (this means it can handle four times as much traffic as standard GPRS).
  - 2G: GPRS provides data rates of 56-114 kbit/s.
- GSM/3G networks are in the best position for upgrading to LTE technology, only relatively minor investments are required as pre-existing base-stations can be upgraded and the process can be managed “at demand”.
- CDMA network operators have also committed to transition towards LTE technology and will be moving to LTE.
- Hardware suppliers are focusing strategy towards LTE (e.g. Ericsson Tesla). There are many new players on the market especially from China, like HUAWEI and ZET that will put further pressure on the prices of the equipment.
- Major Operators have given clear commitments to LTE, including Telia Sonera (has started deployment), France Télécom and Telecom Italia Mobile; DT will also go with LTE

The technology Standard 2 for LTE was finalised in December 2008. For background information on LTE see for instance:
http://en.wikipedia.org/wiki/3GPP_Long_Term_Evolution

3.5.4.6 Satellite Internet

Especially in rural areas where distances are large, markets are small and the economic feasibility for broadband access is difficult, Satellite Internet has proven a viable alternative..

This technology is especially interesting for regions that are sparsely populated. Satellite transmission for downloads offers extremely fast download rates, even surpassing many current broadband technologies.

This technology is not the answer to everyone’s needs, as inherent to it is the slow ping times (latency) that vital for online gaming and VoIP, but network lags are not a issue for non-time-critical downloads which do not start immediately but once they begin they offer very fast rates.

EC selects two companies to provide mobile satellite services
The European Commission has selected Inmarsat and Solaris Mobile to provide mobile satellite services across Europe. The services, such as high-speed internet access, mobile television and radio or emergency communications, will be provided over a specifically reserved spectrum. Mobile satellite services (MSS) are expected to offer wireless communications to millions of EU consumers and businesses with portable terminals carried by a person or mounted on a car or a ship. They can also help bridge the digital divide in the availability of high-speed internet coverage by reaching rural and less populated regions. Member states now have to ensure that Inmarsat Ventures and Solaris Mobile have the right to use the specific radio frequencies identified in the Commission's decision and the right to operate their respective mobile satellite systems. These providers have to be authorised to use their satellite systems all over Europe for 18 years from the selection decision.”

3.5.4.7 Cable Internet

The Cable operators in Croatia are small unofficial units that have for years provided television via cable but have not been arranged as real businesses. They have not kept their hardware up to state, nor have they been market oriented. Today there exists only one viable cable operator B.Net, that offers broadband over cable. Its operations have been expanding and they have triple-play in their product offerings. In addition they have been buying out smaller operators with the goal to grow and become the dominant cable operator in the Zagreb area. Any large scale use is highly unlikely outside the capital area due to extremely high investments required to build up a cable network. Still, for the capital, this is one of the options for the consumers when looking at broadband and triple-play.

3.5.4.8 Dial-up

This is a technology at the end of its life-cycle. Generally, it is predicted that it will remain, for the mid-term, as a "backup" or "marginal" technology. Statistically usage figures are dropping Europe-wide. The same can be predicted to happen in the Croatian market.

3.5.4.9 WiMAX and other Wireless Internet scenario's

Despite the huge marketing hype and technical promise WiMAX offered at launch, it has not been transformed into any noticeable market share in most parts of the world. There are a few developing nations that have used the technology with major investments under specific circumstances, as well as some larger pilot projects in the western countries.

The difficult-to-install technology and lack of mobility has diminished interest in the technology both from the suppliers (difficult and labourous installation process) and consumers (high cost of reception equipment). Similar experiences have been reported in the Croatian market, where the largest WiMAX operator (Optima) has only a few base stations in the Eastern part of the Country. In all likelihood, this will remain a marginal technology. The wait and roll-out of mobile WiMAX might offer a second chance for WiMAX to emerge as a viable alternative to broadband. This remains to be seen.

Some current WiMAX statistics:
- Croatia: Novinet 1.5MKn Turnover, 2 masts, 738 subscriptions
- Finland: Large coverage in Easter Finland, only 200 subscriptions

That said the majority of the experts feel that the window of opportunity of WiMAX has already closed and general perception of the technology has become so negative that it is unlikely to succeed. It can be argued that the potential for the technology was there, similar to Betamax being the superior product to VHS, but in the end, marketing won the VHS battle, and LTE probably will prevail over WiMAX as a the predominant wireless broadband technology.

In summary, the only certainty is that the position of WiMAX as an alternative technology remains uncertain, the most likely future is that of a technology that is used where others are not available for technical or economic reasons..

4 Some developments in telecommunications

4.1 Definition

Telecommunication is the assisted transmission over a distance for the purpose of communication. Telecommunication is an important part of the world economy and the telecommunication industry's revenue was estimated to be $1.2 trillion in 2006. In broad terms, the Telecommunications market consists of Voice and Data traffic.

4.2 Broadcasting signals

There are several broadcasting signal types:

4.3 Unidirectional

This includes the broadcasting of signals from one base station where the reception end has a receiver but is not able to transmit return data. Typical examples of these include T.V. signals and radio.

4.3.1 Interactive

Interactive traffic differs from unidirectional in that traffic is transmitted back and forth, generally in real time. Examples of these include telephony, video-telephony.

4.3.2 Podcasts

Pod casts do not fit nicely into the simplistic model of Unidirectional vs. Interactive signal types. In essence, Pod casts generally can belong to either group. Interactive Pod casts technically are Interactive in that one end "orders" a transmission to commence, can pause it, and also can stop the transmission, still the bulk of the traffic is sent from the "server-end".

An example of this is video-on-demand (now low-bandwidth, but going towards High-Definition (HD).

4.4 Transfer Technology

Taking a quick look at transfer technologies, there are two main types: streaming and non-streaming. These two transfer technologies have different requirements; mainly they are distinguished by time-critical requirements and/or delivery.

On the application layer there are two key issues

1. bandwidth,
2. latency

Bandwidth should be considered as the measure of traffic volume. Latency measures the time it takes for data to travel from sender to receiver. These concepts can be compared to the number of lanes on a highway and the speed limit on the road. To date, no systematic approach exists how to address these requirements, although it can be argued that given enough bandwidth capacity, latency issues will also be addressed. Sometimes it is not so much the latency itself that matters but differences in latencies.

4.4.1 Bandwidth discrimination

This term describes the policy of giving certain types of data priority over less time critical data. In essence, the principle is similar to favouring public transport by setting aside special lanes for busses to use with the attempt to allow them to circumvent traffic jams. For data, the objective is to prioritize time-critical transfers. Put simply, its more important to have Voice over Internet (VoIP) data with fewer lags, prioritizing it over email transfers, for example. Current technologies use ports to prioritize data by type, which is by design relatively unreliable but still used as no better approach exists using the Internet Protocol version 4 (IPv4). This issue will be remedied by IPv6 in the future as this protocol contains inbuilt control data and package descriptors, allowing the implementation of a robust system for bandwidth discrimination.

For the telecommunications sector, the approach thus far has been to design overcapacity of bandwidth into the network just to ensure that everything goes right. This was made possible by the steadily decreasing costs of bandwidth.

4.5 Classic Telecommunications vs. the Internet

Current Telecommunications legislation is generally discriminates between voice, data, video and broadcasting. With the general trend towards IP based technologies even in the conservative telecommunications networks, the divide between Telecommunications and the Internet is becoming increasingly unclear. It can be argued that all digital traffic is data traffic.

While classic telecommunications experts see the Internet as wrapping into the telecommunications market, Internet experts could argue that the classic telecommunications market is being swept into the Internet market as simply several of the many applications. Both arguments have their points but what is important to note is that the two are merging into one.

4.5.1 Quality and Reliability

Telecom, as an established industry, has placed focus on dependability. Generally, the quality of IT is considered well inferior to classic telecommunications systems. This is well inline with the theories of emerging technologies, where initially the focus of development is in the technologies themselves, and as the technologies stabilize, more attention is given towards reliability and the fine-tuning of existing systems.

One of the key questions posed is how to get the reliability of Internet Technologies in line with the expectations of classic Telecommunications users, especially as it is increasingly probable that the two technologies are becoming one and the same?

4.5.2 Is telecom the Internet?

Increasingly, the robustness of IP technology is pushing many aspects of "telecom" towards all-IP based solutions. If telecom today is not the Internet, it probably soon will be. That is assuming that the Internet is defined as the Internet Protocol (IP) data transfer technology.

4.5.3 Is the World Wide Web (WWW) the Internet?

A few years ago, there was strong evidence that the Internet was not the same as the World Wide Web. Purists classified the WWW as one technology within the Internet; specifically the Hyper Text Transfer Protocol (http) allocated the port 80. Later the secure encrypted https protocol was included into the WWW at port 443. Over time, there have been further additions into WWW technology.

The WWW is by far the most dominant technology of the Internet today. Others include Email, Newsgroups, VoIP technologies etc. just to mention a few. Consumers often speak of the Internet, when they mean WWW. This is also true inversely.

4.6 The Future as seen by Sir Tim Berner Lee, the Inventor of the World Wide Web:

It is impossible to predict the future especially in the field of Internet Technologies, but one may always speculate what the future will bring. One lesson that has been learnt over the years is to expect the unanticipated. Another lesson is to be very careful with size, speed and growth estimates. If past experiences are any indicator, all estimates will fall short of actual figures, so expect more!

Tim Berner Lee has Three Predictions for the future:

First, the Web will get better and better at helping us to manage, integrate, and analyse data.
Today, the Web is quite effective at helping us to publish and discover documents, but the individual information elements within those documents (whether it be the date of any event, the price of a item on a catalogue page, or a mathematical formula) cannot be handled directly as data. Today you can see the data with your browser, but can't get other computer programs to manipulate or analyze it without going through a lot of manual effort yourself. As this problem is solved, we can expect that Web as a whole to look more like a large database or spreadsheet, rather than just a set of linked documents.

Secondly, the Web will be accessible from a growing diversity of networks (wireless, wireline, satellite, etc.) and will be available on a ever increasing number of different types of devices.

Thirdly, in a related trend, Web applications will become a more and more ubiquitous throughout our human environment, with walls, automobile dashboards, refrigerator doors all serving as displays giving us a window onto the Web.

The future of the Internet growth in bandwidth availability shows little sign of flattening; even in the present economic circumstances there still is substantial growth in traffic on the major Internet Exchanges all over the world. Home users can expect increased capacity through cable, phone, and wireless networks. With wired technologies, Fiber-To-The-Home (FttH) will vastly increase bandwidth availability. In mobile Long Term Evolution (LTE) as a form of 4Th generation technologies (4G) will push wireless broadband into the mainstream as a viable option for the consumers. High resolution audio, video, and virtual reality will be increasingly available online and on demand. The cost of all kinds of Internet connections will continue to drop. "The evolution of the Web is not in the hands of any one person"[2].

4.6.1 Several Key Points about the future of the Internet as mentioned by Tim Berner Lee

A. Data Integration

Digital information about nearly every aspect of our lives is being created at an astonishing rate. Locked within all of this data is the key to knowledge about how to cure diseases, create business value, and govern our world more effectively. The good news is that a number of technical innovations like Resource Description Framework[3] (RDF) which is to data what HTML is to documents, and the Web Ontology Language (OWL) which allows us to express how data sources connect together) along with more openness in information sharing practices are moving the World Wide Web toward what we call the Semantic Web. Progress toward better data integration will happen through use of the key piece of technology that made the World Wide Web so successful: the link.

[2] http://dig.csail.mit.edu/2007/03/01-ushouse-future-of-the-web.html
[3] The Resource Description Framework is a family of World Wide Web Consortium specifications originally designed as a metadata data model. It has come to be used as a general method for conceptual description or modelling of information that is implemented in web resources; using a variety of syntax formats.

The power of the Web today, including the ability to find the pages we're looking for, derives from the fact that documents are put on the Web in standard form, and then linked together. The Semantic Web will enable better data integration by allowing everyone who puts individual items of data on the Web to link them with other pieces of data using standard formats.

To appreciate the need for better data integration, compare the enormous volume of experimental data produced in commercial and academic drug discovery laboratories around the world, as against the stagnant pace of drug discovery. While market and regulatory factors play a role here, life science researchers are coming to the conclusion that in many cases no single lab, no single library, no single genomic data repository contains the information necessary to discover new drugs. Rather, the information necessary to understand the complex interactions between diseases, biological processes in the human body, and the vast array of chemical agents is spread out across the world in a myriad of databases, spreadsheets, and documents.

Scientists are not the only ones who need better data integration. Consider the investment and finance sector, a marketplace in which profit is generated, in large part, from having the right information, at the right time, and reaching correct conclusions based on analysis and insight drawn from that information. Successful investment strategies are based on finding patterns and trends in an increasingly diverse set of information sources (news, market data, historical trends, commodity prices, etc.). Leading edge financial information providers are now developing services that allow users to easily integrate the data they have, about their own portfolios or internal market models, with the information delivered by the information service.
The unique value creation is in the integration services, not in the raw data itself or even in the software tools, most of which will be built on open source components.

New data integration capabilities, when directed at personal information, pose substantial privacy challenges which are hardly addressed by today's privacy laws. The technology of today's Web already helps reveal far more about individuals, their behaviour, their reading interest, political views, personal associations, group affiliations, and even health and financial status. In some cases, this personal information is revealed by clever integration of individual pieces of data on the Web that provide clues to otherwise unavailable information. In other cases, people actually reveal a lot about themselves, but with the intent that it only used in certain contexts by certain people. These shifts in the way we relate to personal information require serious consideration in many aspects of our social and legal lives. While we are only just beginning to see these shifts, now is the time to examine a range of legal and technical options that will preserve our fundamental privacy values for the future without unduly stifling beneficial new information processing and sharing capabilities. Research at Massachusetts Institute of Technology (MIT) is investigating new technologies to make the most of the Semantic Web, as well as both technical and public policy models that will help bring increased transparency and accountability to the World Wide Web and other large scale information systems. The belief is that in order to protect privacy and other public policy values, the is a need to research and develop new technical mechanisms that provide great transparency into the ways in which information in the system is used, and provide accountability for those uses with respect to what ever are the prevailing rules

The overall effect of these developments will be that the need for more bandwidth will last.

B. Network Diversity and Device Independence

The Web has always been accessible from a variety of devices over a variety of networks. From early on, one could browse the Web from a Macintosh, a Windows PC or a Linux-based computer. However, for a long time the dominant mode of using the Web was from some desktop or laptop computer with a reasonably large display. Increasingly, people will use non-PC devices that have either much smaller or much larger displays, and will reach the Internet through a growing diversity of networks. At one end of this spectrum, the devices will seem more like cell phones. At the other end, they will seem more like large screen TVs. There are, of course, technical challenges associated with squeezing a Web page designed for a 17 inch screen into the two to four inch display available on a mobile smart phone or PDA. Some of these will be solved through common standards and some through innovative

new interface techniques. All of this means more convenience for users and more opportunity for new Web services that are tailored to people who are somewhere other than their desks.

Growth in access networks and Web-enabled applications presents a number of important opportunities. For example, more robust, redundant network services together with innovative uses of community-based social networks on the Web are coming to play an increasing role in areas such as emergency planning and notification. Reports about ad hoc communication networks supporting disaster relief efforts are just one illustration of the benefit of the openness, flexibility and accessible of the Internet and Web. This one area is a microcosm of many of the issues that are being discussed today, because in order to work well it requires seamless integration of diverse types of data; repurposing that data instantly into valid formats for a myriad of different Web devices; and including appropriate captions, descriptions, and other necessary accessibility information.

C. Ubiquitous Web Applications

In the future, the Web will seem like it's everywhere, not just on our desktop or mobile device. As LCD technology becomes cheaper, walls of rooms, and even walls of buildings, will become display surfaces for information from the Web. Much of the information that are received today through a specialised application such as a database or a spreadsheet will come directly from the Web. Pervasive and ubiquitous web applications hold much opportunity for innovation and social enrichment but also pose significant public policy challenges. Finally, inasmuch as this new ubiquitous face of the Web is public, it will shape the nature of the public spaces we work, shop, do politics, and socialize in.

D. The Web is Not Complete

Progress in the evolution of the Web to date has been quite impressive. But the Web is by no means finished.

The Web, and everything which happens on it, rest on two things: technological protocols, and social conventions. The technological protocols, like HTTP and HTML, determine how computers interact. Social conventions, such as the incentive to make links to valuable resources, or the rules of engagement in a social networking web site, are about how people like to, and are allowed to, interact.

As the Web passes through its first decade of widespread use, there still is known surprisingly little about these complex technical and social mechanisms. We have only scratched the surface of what could be realized with deeper scientific investigation into its design, operation and impact on society. Robust technical design, innovative business decisions, and sound public policy judgment all require that we are aware of the complex interactions between technology and society.

From all of these developments it is clear that reliable very high broadband communications are crucial in the future.

Further key developments for the Internet are summarized in the section below:

4.7 Globalism

The process of globalism and internationalization of the Internet will continue further. People will have access to any information they wish, get smarter sooner, and be more aware of the world outside their local environment. A better informed humanity will make better decisions. Human perception will further expand from community level to Earth-wide global perceptions.

4.8 Communities

Not everything about the Internet is global; an interconnected world is also locally interconnected. Local communities can and will utilize the Internet for communication.

Sectoral networking will not be limited by physical proximity but increasingly allow virtual participation in ways that so far have only been conceptualized. Telecommuting, Teleconferencing and remote virtual participation will move from exotic technologies to everyday household events.

4.9 Virtual Reality

With the continued doubling of computer capability every couple of years, and with the ever increasing bandwidth being made available for use, the ability of technology to process the complex analogue environment that humans live in -- "reality" -- will continue to increase, and will be increasingly integrated with the Internet. Virtual reality applications will not only better and better reflect the natural world.

4.10 Bandwidth:

The predictions of the future of the demand for bandwidth remains high. Even economic fluctuations like the present downturn seem to have little effect on these growth trends.

4.11 Moore's Law on processing power[4]

Moore's law describes a long-term trend in the history of computing hardware. Since the invention of the integrated circuit in 1958, the number of transistors that can be placed inexpensively on an integrated circuit has increased exponentially, doubling approximately every two years.

Almost every measure of the capabilities of digital electronic devices is strongly linked to Moore's law: for instance processing speed and memory capacity. All of these are improving at (roughly) exponential rates as well.

4.11.1 Nielsen's Law of Internet Bandwidth[5]

Nielsen's Law of Internet bandwidth states that:

"A high-end user's connection speed grows by 50% per year."

Nielsen's Law is similar to the more established Moore's Law. A comparison of the two Laws shows that bandwidth grows slower than computer power, thereby necessitating some of the processing power to be used to squeeze data in lower bandwidth channels.

	Annualized Growth Rate	Compound Growth Over Ten Years
Nielsen's Law Internet bandwidth	50%	57x
Moore's Law Computer power	60%	100x

Average available bandwidth increases more slowly for three reasons:

1. Telecoms companies are conservative: they need to dig up streets and install equipment in hundreds of thousands of central offices so they think twice (or thrice) before investing the necessary billions of dollars. Even after they invest, it takes time to update their sprawling physical plant.
2. Users are reluctant to spend much money on bandwidth. If you buy twice as fast a computer, your software runs twice as fast; if you buy twice as large a hard disk, you

[4] http://en.wikipedia.org/wiki/Moore%27s_law
[5] http://www.useit.com/alertbox/980405.html

can store twice as many files. But if you buy twice as fast a modem, then you don't download Web pages twice as fast: the speed of the Internet is a function of both the individual user's connectivity and of the infrastructure. You don't get the full benefits of your own bandwidth upgrades immediately -- only gradually as the Internet and the host servers improve.

3. The user base is getting broader all the time as mainstream users get online. These new users are more likely to be low-end users than high-end users (all the geeks have been online for years), so the average shifts ever lower and for the time being the need for bandwidth is spread very unevenly over users. As experienced in Croatia where besides ADSL there still is a substantial dial up access to the Internet.

Jakob Nielsen[6] is a leading web usability consultant

4.12 Wireless

Wireless Internet offers two great advantages

1. There are no infrastructure start-up or maintenance costs other than upgrading the base stations.
2. It frees users to become mobile.

Wireless Internet will offer increasingly faster services at vastly lower costs over wider distances. However, if it really can push out fixed transmission systems to end users remains to be seen.

4.13 Grids

The future of the Internet grid movement is most probably inevitable. The connection of thousands of computers on the Internet together to solve problems will continue to evolve and change many areas of human endeavour. Un-used computer cycles from home users across the world will be harnessed together to provide enormous reservoirs of computer power for all sorts of purposes.

4.14 Internet2

The future of the next generation Internet is commonly referred to as the Internet2 project[7]. Internet2 is a not-for-profit advanced networking consortium that actively engages in the development of important new technology including middleware, security, network research and performance measurement capabilities which are critical to the progress of the Internet. The Internet2 community pioneers the use of advanced network applications and technologies, from their academic inception through their evolution to the commercial Internet.

All of this shows the highly likely continuing increase in demand of transmission capacity.

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