# Optical networks and network strategies

GYÖRGY TAKÁCS

*Péter Pázmány Catholic University, Faculty of Information Technology*

*takacs.gyorgy@itk.ppke.hu*

***Keywords: Gilder theory, Development of transmission bandwidth, Telecom policie***

*The revolutionary development in telecommunication and information technology is based on several roots. The critical mass of users (sometimes above one billion people) is often mentioned concerning mobile phones and computers, services, applications. Other important issue might be the fierce competition on the global ICT market. A very important factor in this competition to come first to the ICT marketplace with relevant new products and services. There is no ultimate winner in this competition for long run. Day by day the competition starts again and technical novelties push the market into new direction.*

## 1. Introduction

Which directions of technology development promise the best future? How to prepare ourselves to survive the changes or even be leaders? What are the tasks of system suppliers, service providers, users, regulatory bodies, governments to provide better position to the human society by this game? Which fields promise good business, source of tax money, and benefit for end users?

These are really difficult questions. It is absolute impossible to be good fortune teller in this field by eternal statements. The aim of this paper is to stimulate thinking of experts in this field. Might be some elements of this paper are quite provocative. We have to recognise, that bandwidth grows fastest and transmission capacity has less direct limit in growth. Bandwidth is mentioned as a third category, simple technical issue. It has chance, that from enabler category the bandwidth issues will lift to the level of killer category. Tracking back of the stock exchange figures we can detect an opposite trend! Papers of high speed network companies are low now. However there are several optimistic analysers concerning bandwidth.

Facts are reviewed here in a strange sequence. Detailed analysis is done but the customised conclusions remain for readers.

## 2. Development of technology concerning bandwidth and related fields

The future of networks depends on the development speed and costs of the following items:

- processing one bit,
- transmit one bit,
- store one bit.

The future network philosophy is determined by the winner of the items listed above.

Well known laws summarise the development trends of items above. They all show exponential growth in time. The exponential curve is very steep at all but the value of exponent is highest at bandwidth. Consequently the fastest growth is at bandwidth. The processing power is doubled within 1.5 years, the bandwidth is tripled within one year, and storage capacity is doubled within one year.

The winning position of the bandwidth can be derivated from the value of exponent. An other frequently mentioned fact is that nanotechnology or novel processing ideas are necessary because the physical limits seems to be near in the development possibilities of traditional chip technologies. Hopefully the chip technology will find also new lines of further development to override the limits in

| | |
|---|---|
| Moore law on processing power | The processing power is doubled in 18 months |
| **Gilder law on bandwidth** | **The total bandwidth of global communication system is tripled in 12 months** |
| Metcalf law on the value of networks | The potential value of networks is proportional with the sqare of the number of users |
| Shugart law on the price of storage capacity | The price of magnetic storage related to one bit is halved in 18 months |
| Ruettgers law on storage capacity | The storage capacity is doubled in 12 month |
| Wacker law on metadata | Any information related to the transaction has higher value than the transaction itself |

technology e.g. to solve the thermal problems of big and high speed chips. However such problems do not exist in development of transmission bandwidth.

One carrier frequency in one optical fibre can transmit 10 Gbit/s. In one fibre 1000 carrier can be implemented and in one cable 1000 fibre is feasible. Multiply these figures the result shows that the theoretical transmission capacity of such a cable is about $10^{16}$ bit/s/. This cable has about one inch diameter, consist of 1000 fibre and in each fibre we can use 1000 carrier. Can we say that the transmission capacity of such a cable is practically infinite? Yes and a simple example may prove it. The normal life time of a human person is about 80 years that means 2,5 x $10^9$ seconds. The most advanced coding procedures needs about 1Mb/s, to store or transmit good quality video signals. So our example cable can transmit in 1 second so many video signals, which can be watch by 4 persons during 80 years (24 ours per day). The transmission capacity of such cable can be characterised by this 4 life-long video signal transmission in one second.

The same time we can state that we are in the age of practically free bandwidth also. Let us bring an example again to prove it. Hungarian Universities and academic institutions are connected to the HUNGARNET network typically by 1,5 Gigabit/s fibre links. A normal monthly fee paid by institutions for a dark fibre leased line service to transport bits takes 200.000 HUF. The costs of equipment like media converters or routers are not included.

This leased line cost can be considered practically free. A tram ticket takes 125 HUF in Hungary. Using the full download speed 125 HUF takes 27 minutes downloading or downloading of 2430 Gigabits or downloading 6,75 hours good quality video or full content of hard discs of 30 personal computers. So practically the transmission costs can be considered free! That is a quite different question that the theoretical bandwidth is really utilised very low level. The transmission capacity is utilised by few percent during nights or weekends.

As other result of the fantastic development in optical transmission technology we can state, that the geographic distances in the globe are eliminated. The world record in fibre cable attenuation does not exceed 0.001 dB/km. This means that by one hop Hungary and any town of the USA can be directly connected with optical cables! It does not matter whether transatlantic or transpacific routes are used but amplification is not needed.

The NASA homepage has detailed *description of the system producing such optical cable.* On the board of Columbia space shuttle were tested the system several times to produce extreme clean glass fibre in microgravity environment.

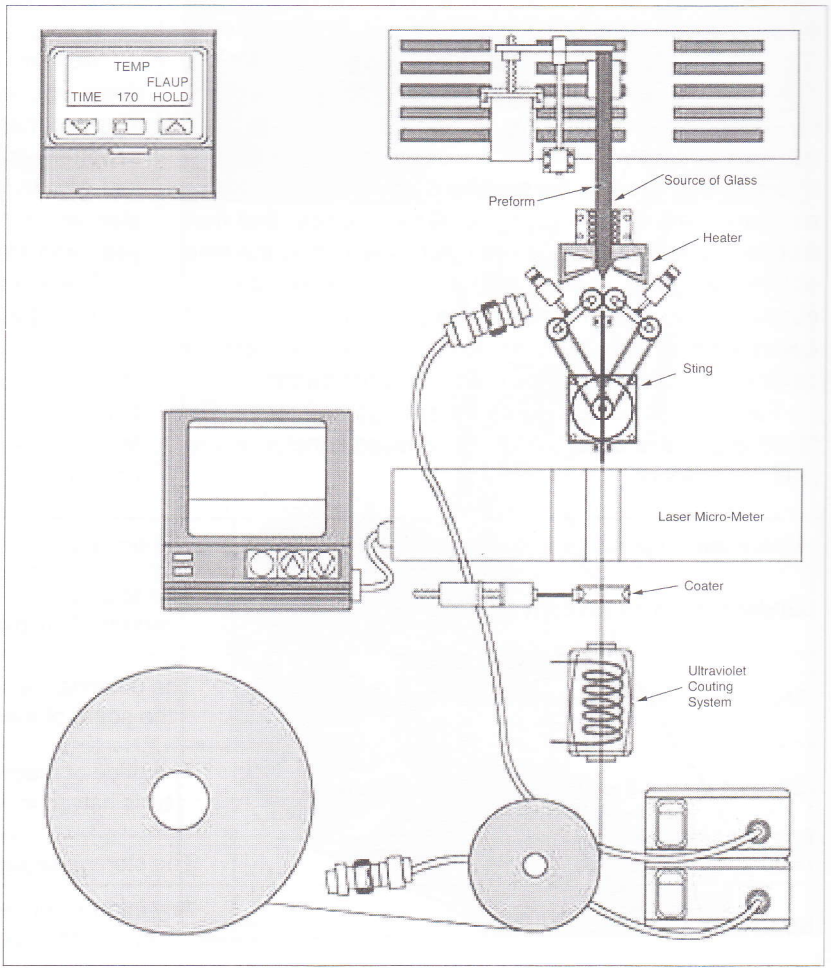
The fibre diameter is precisely controlled by the pulling speed and the fibre is immediately coated. We have to mention that the raw materials are available all around the globe with practically unlimited amount (not the same concerning copper because the copper resources of the globe are more and more limited).

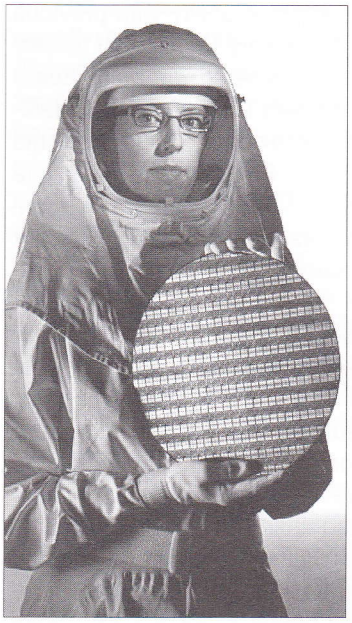
Why can we calculate with real explosion in the field of information technologies as a result of fast development in transmission capacities? Because the real basic practice will changed radically soon. As the development speed of processing power and the memory capacities is high enough this two factors together speed up the demand for transmission capacity too. The new solutions will spread mostly in the best developed areas of the world. So the winners and losers of new results will be even more divided.

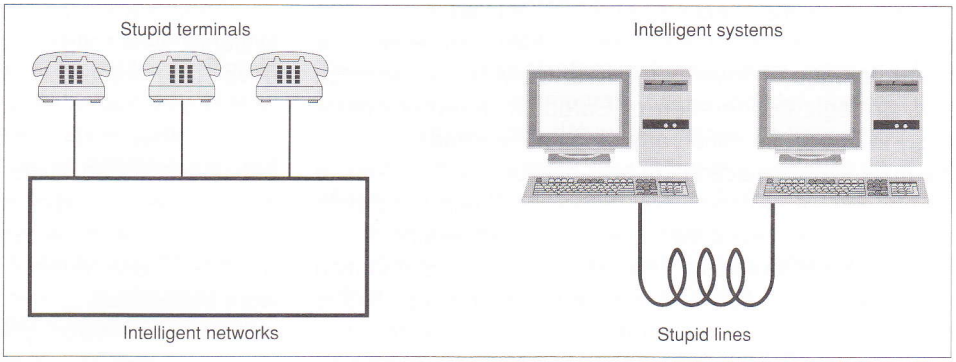
## 3. Impacts on network and service structure

The unlimited and free bandwidth has serious consequences on the development of network structure, on the network operation and on the services.

The unlimited and almost free goods have no high respects and not so easy to make profitable business on them – except stimulating wasteful applications. Even in the field of electronic engineering can be mentioned other wasteful applications: in 1970 the price of one transistor








was about 1 USD but today in a high scaled CHIP 0,000 000 025 USD costs one transistor. In one chip billions of transistors can be produced and an example *foto* is shown below.

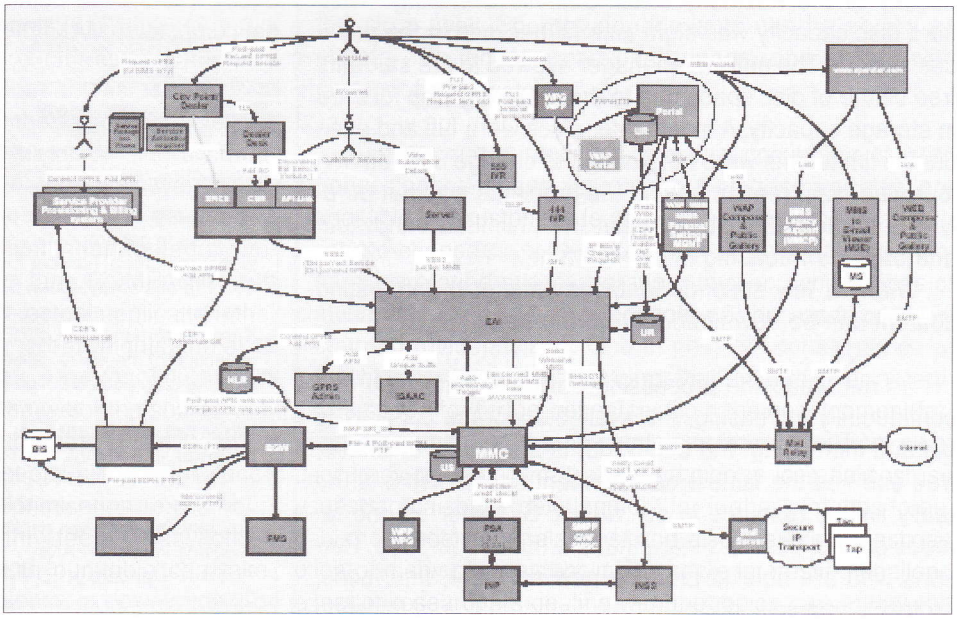
Companies make good business on practically free transistors. Only trick is to stimulate wasteful using of them. Consider please the up to date personal computers! They consist of billions of transistors. In spite of almost free transistors the complete computer has profitable prise. Hysteric campaigns are initiated to increase quickly the number of computers in Hungary! We have to follow the official statistic figures of the global leaders! Remember please the typical application of a personal computer (the application of billion of transistors in each)! Billions of bits are used for games or for screen savers or animated symbols in the help menu. Our fathers used a pack of cards for comparable games instead of billions of transistors with a sophisticated software package on the top of it. The real problem is not only the wasteful application but pulling the development towards the even more wasteful solutions without the critical thinking of other promising principles. It is time rethinking the principles of information technologies! It is time to analyse the consequences of wasteful usage of bandwidth.

## 4. Conclusion

New network structures and new roles of network nodes come with the wasteful bandwidth applications. In the traditional telecom networks had high level intelligence in the networks and stupid terminals were at the ends. In the computer networks the terminals were very intelligent and the network functions were considered primitive level, mostly as simple transparent bit-pipes (one bit in-one bit out) and similar simple network functions in nodes (controlled by terminals). The main difference is flow control. The essential features are represented in the *figure (above)* below.

One of the global leaders in systems demonstrated a new system concept. This system supports mobile users, standardised network components, different service providers, different application providers, shared network functions, authentication of users, billing systems... The service creation and provision functions, the access and transport functions, the application creation and provision functions are implemented in harmony of competition oriented multi provider environment. Elementary functions to find the mobile users, making the identification, authentication and authorisation process, providing correct data record for fair billing, meantime protect the rights of personal data...

The *figure (down)* below shows an example of implementation of such network functions. The names of individual boxes have not importance but the complexity of network structure is really interesting. The present telecom operators calculate fees mostly based on call minutes, so somehow they charge the used bandwidth. The network intelligence and mostly the content fees are mostly transformed into the charges of bandwidth. This network structure don't suggest development towards the free and unlimited bandwidth and extreme bandwidth stupid networks.



Mr. Carelli, the director of EURESCOM had a very interesting presentation in Budapest in 2001 concerning the next generation networks. (EURESCOM is the research and strategic cooperation of European network operators.) In this presentation one of main messages was that the main factor selecting the best network mode seems to be the cost of switching technologies. Cheap bandwidth suggests rather circuit switching, cheap processing power prefers packet switching. The concentration or distribution the network intelligence is a quite different issue. This is not a cost factor but rather question of technical feasibility. Packet switching of the above mentioned $10^{16}$ bit/s bit stream is not expensive but not realistic. Even one per cent of this bit flow is more above the processing capabilities of the fastest processing chip.

Relevant new (or re-invented) solutions in the network world are quite common. Remember the suggested network topology by A.G. Bell: this was a fully meshed structure. A very similar structure is suggested by G. Gilder for unlimited bandwidth optical networks. The invention of telephone switchboard by T. Puskás some years after the invention of telephone introduced the rational management with lines or with other words the rationalisation of bandwidth.

Using other words the unlimited bandwidth connections and meshed or ring network topology can be utilised as the traditional radio broadcasting: send the information flow everywhere and the selection of the relevant information is the task of the user at the receiving terminal. It is a logical question where can we put so many fibre cables? The existing duct system has space enough removing the copper cables – there is no risk to destroy pedestrian ways in towns.

Relevant new user behaviour can emerge by the free and unlimited bandwidth. Even the author of this paper has recognised that it is faster downloading a file from the net than find it in an unknown map with unknown name in the hard disc. In spring time of 2003 a new computer series was introduced at the Information Technology Faculty of the Pázmány Péter Catholic University. Their hard disc capacity was eight time higher than in the previous system. The network manager allowed to the students free usage of disc space due to the really big step forward in storage capacity. A month later discs were full and even drastic limitations were not enough to change user behaviour. The main reason behind the problems was not purely the storage capacity limit but the unlimited bandwidth and easy downloading of any content.

Within a few seconds fantastic amount of interesting content can be downloaded from the net.

In our world the processing power is quite high and continuously increasing, the available storage capacity is big and increasing; the bandwidth is practically unlimited, free and has the fastest development speed. What is the really limited resource in our world? G. Gilder as one famous guru in this field state that the human persons. Persons who are able to produce new software, interfaces, protocols, network standards – for smooth communication of information systems, and interoperability with previous systems. New solutions are necessary to utilise of quickly developing resources. Gilder forecasted the quick death of networks having stupid terminals like telephone or television. Gilder predicted high intelligence in the networks but concentrated at the edges. For example in mobile phones the processor, memory, display, camera .... considerable exceed the capabilities a normal PC in the early nineties. These terminal functions are organic part of network intelligence.

The new network philosophy suggested by G. Gilder promise a new age in content provision as well. Any content will be available in any time and any place. The main difference between the traditional TV broadcasting and the new download based content provision can illustrated by the following example. Travel by train is comfortable but you have to adapt to the time table have to go to the railway station, and your travel partners can not be chosen. By car you can departure when you wish, can stop where you want, you can select your partners, and you can change routes even meantime. If any content accessible for you, then the absolute freedom might be available for you to compose the actual and individual information, learning and amusement program without standing from your armchair. For such networks and services new companies are required. The existing firms hope better profit by traditional services. Probably pioneer companies initiate revolution in network and service structures.

What is the connection of bandwidth development to relate other factors? What is the perspective in processor power? A serious limit is the heating. The forced air heating is problematic to keep normal temperature in the processor chip. Water heated PC processors means one possible heating solutions. Several companies demonstrated water-heated processors in CeBIT 2003.

Developments in storage capacities have nice figures also. IBM provided in 2003 personal computers with 400 GB hard discs as well. In 1998 the average hard disc capacity was 5,1 GB but in 2002 36,1 GB in shipped personal computers (MAXTOR).

*Fixed Wireless Technology*

**802.11 To Get Speed Boost?**

The IEEE has a study group pushing for new standards to officially bring throughput levels for wireless LANs up to 108Mbps—or faster.

While many vendors have played with the technology of 802.11 products to get proprietary speed boosts of 72 Mbps and even 108 Mbps, the official number for the maximum speed with 802.11a and 802.11g has always been 54 Mbps. But that might change. Unstrung.com is reporting, based on a conversation with Stuart Kerry, chairman of the IEEE's 802.11 Working Group, that a collection of members called the High Throughput Study Group is working on a potential high-performance standard that would boost both 802.11b (now at 11 Mbps) and 802.11a standards.

**While not official yet, this standard for increased throughput might be called 802.11n. Proposals say it could go to 108 Mbps or beyond—as much as 320 Mbps.**

The speed increase would take place due to the handling of problems such as lost packets, interference, and other issues that regularly impact WLANs.

This new standard is not expected to be complete until 2005 or 2006.

The optical cables today connect network nodes but usually not the user terminals. The last mile links need higher and higher bandwidth. The high speed utilisation of twisted copper pairs means one promising mode of high bandwidth connection. The wireless connections have also revolutionary development. As a new example the start of 802.11n WLAN standard by 300 bps links can bring new waves in wireless connections replacing the 802. 11b version of 11 Mbps links. The fibre connection can be terminated at small WLAN base stations. The end users can connect by short distance high speed radio link providing real full conform.

In 2003 six chip suppliers have full chip set for the 802.11.b standard and a WLAN card for notebook take a couple of ten USD only.

These rapid developments in technology promise big changes in the field of services as well. Analysts predict competition of 3rd generation mobile systems and WI-FI in US. An example copy of headline news tries to indicate below the stile of starting competition:

Issue 11.05 UNWIRED –
A Wired Special Report - May 2003
**Good-Bye 3G - Hello Wi-Fi Frappuccino**
**Cellcos bet big on third-generation wireless - and took a big hit. Now T-Mobile's John Stanton has a grand convergence plan. Starbucks is just the beginning.**
*By Dan Briody*

According to the opinion of some journalists the 3rd generation mobile systems are failed even before the real start. The WLAN based services using their popular name WI-FI have aggressive rollout plans starting from public places. The T-Mobile in US cooperating with STARBUCKS started an attractive combination of services. Sit down; use the internet with your notebook and the free coffee is only an addition to other services. Phone calls naturally are included in the service set. Such service combination might be really promising in a big country where the mobile penetration and the radio coverage are far behind European figures. Most of the services and applications planned in the 3rd generation mobile will be implemented in WI-FI as well. It is a future question whether free coffee comes to the charged internet or free internet usage to the charged coffee.....

The mobile operators (using the new fashion word "cellco-s") have paid in Europe very big sum of money for the 3rd generation service licences or for frequencies. The new competitors use free frequencies for WI-FI! Might be the high frequency fees spoil cellcos or funny small things like coffee can bring the good balance.

One of the interesting consequences of cheap access to big information might be the end of intellectual proprietary rights. The big market turbulence in downloading or changing music records by internet seems to be only beginning of the whole process. Due to the free bandwidth there is no reason to store at home books, films or CD-s. Downloading for momentary use is simpler. Authors frequently support real global free access to their products.

The free bandwidth can make the globe even more comfortable or sustainable. Instead of sitting in the car and driving to work, learning or enjoy the life the teleworking, telelearning and other applications can spare a lot of fuel or can help to reduce the terrible road traffic.

The downloaded content can be clean from dirty advertisements. The media industry in the downloading age can separate real programs and advertisements.

One of the potential utilisation of infinite bandwidth might be to apply many cameras and propagate their signal. A lot of news can be found on the net concerning cameras.

**Not Terrorist but voyeur was on the board of luxury ship**

An American luxury ship was evacuated on Thursday evening because one of the passengers informed the staff on a suspicious object with wires in the lavatory.
After carefully search it was recognised that no explosive but small camera was in the lavatory for ladies.

**HP is working on wearable digital cameras**

HP develops digital cameras which can be wear as a part of the clothing and can continuously record important event of the user's life.

Cameras as part of clothing can be sort according to the cloth stile. So records of events can be sorted as events with jacket, events with jeans, and events with swimming dress....

Telelearning is predicted as a real competitor of traditional contact based education. Complete courses are available free on the net (e.g. MIT OpenCourseWare 2002). So called "professor-less" courses and telelearning communities have been started (peer-to-peer communities of students). Experts and professors will be used mostly in charged teleconsulting. One of possible consequence of the wide spreading telelearning, that the certificatory institutions of knowledge will not be the traditional universities. Teachers mention that students can learn a lot from each other. Especially information technology is a field where fathers can learn from sons.

If the real future is the downloading age how could we find the desired content in the endless WEB? We hope that the development of search engines can follow the

content production. In text based search the application of higher level language technology is inevitable. The association based procedures do not fit to the traditional serial processing methods. Content based search of videos and music records are at the very beginning.

## 5. Summary

In the age of unlimited bandwidth new perspective are for the development of telecommunication and information technology. Good highways stimulate road traffic so high bandwidth networks will transport more and more information serving even wasteful but useful applications. The listed examples and applications demonstrate the actual situation and help to understand the real direction of development. Conclusions sometimes are extravagant but better to bring bigger umbrella and close it in sunshine than only a very small one and become wet even in small rain.

### References


[1] Report of the Transatlantic Networking Committee
http://www.uscms.org/s&c/reviews/doe-nsf/2001-11/docs/TAN-report-final.doc.pdf

[2] dr. Takács György:
Next generation networks – George Gilder gondolatai
PKI Tudományos Napok, Bp., 2002. nov. 19-20.

[3] Wireless Networking
Wireless networking news, publications and reviews
http://bengross.com/wireless.html

[4] Mobility Networks Overview
Bringing WLAN to Macro-networks
http://www.mobilitynetworks.com

[5] Good-Bye 3G – Hello Wi-Fi Frappuccino
http://www.wired.com/wired/archive/11.05/unwired/convergence.html

[6] Georg Gilder:
TELECOSM How the Infinite Bandwidth Will Revolutionize Our World
The Free Press, New York 2000.

[7] David Futrelle:
Was Georg Gilder Blinded by the Light?
www.business2.com/articles/web

[8] Charle Sanders:
The Late, Great Telecosm?
www.spectator.org/AmericanSpectatorArticles

[9] Gary Rivlin:
The Madness of King George
www.j-bradford-delong.net/Stray_Notes/gilder_wired_2002-07.html

[10] David S. Isenberg:
The Dawn of the Stupid Network
www.isen.com/papers/Dawnstupid.html

[11] David Isenberg:
Rise of the Stupid Network
www.hyperorg.com/misc/stupidnet.html

[12] Microgravity Fibre-Pulling Apparatus
www.nasatech.com/Briefs/Dec98/MFS26503.html


## ITU-News

The International Telecommunication Union published a **new standard that allows content providers to roll out value-added interactive TV (iTV) services** to any network without modification. ITV allows viewers of a football match for example, to display data on a player while a match is in progress. The standard means that content providers can develop interactive material for programmes that can then be distributed worldwide without extra labour or cost. It means the content will stay true to the author's desingn in all markets – a key concern for advertisers. A key feature for industry is the flexibility of the standard that allows operators to design individual content and easily tag-on interactive content to their programmes.

ITU-T J.202 consolidates the work of other standards makers illustrating ITU-T's position for coordination of Information Communication Technology standards.

The **first global index** to rank Information and Communication Technology (ICT) access has turned up some surprises. Slovenia ties France and the Republic of Korea, usually not among the top ten in international ICT rankings, – comes in in fourth. Apart from Canada, ranked 10th, the top ten economies are exclusively Asian and European. The Digital Access Index (DAI) distinguishes itself from other indices by including a number of new variables, such as education and affordability. It also covers a total of 178 economies, which makes it the first truly global ICT ranking.

Countries are classified into one of four digital assecc categories: high, upper, medium and low. Those in the upper category include mainly nations from Central and Eastern Europe, the Caribbean, Gulf States and emerging Latin American nations. Many have used ICTs as a development enabler and government policies have helped them reach an impressive level of ICT access. This includes major ICT projects such as the Dubai Internet City in the United Arab Emirates, the Multimedia Super Corridor in Malaysia and the Cyber City in Mauritius. The DAI will be a useful tool for tracking the future advancement of these ambitious emerging economies.