New generation media in research and entertainment

Authors
Artur Binczewski, Maciej Glowiak, Bartlomiej Idzikowski, Maciej Stroinski, Maciej Strozyk
artur@man.poznan.pl, mac@man.poznan.pl, idzik@man.poznan.pl, stroins@man.poznan.pl, mackostr@man.poznan.pl

Abstract
The growth of the display resolutions determined by new research and development makes many ideas related to the new media projects over the world possible. However, the 4K resolution, that becomes next leading technology beyond High Definition, is very demanding. There is need to increase network bandwidth, storage size and processing performance in order to satisfy new applications that operates 4K or higher resolutions. Building the European infrastructure for new generation media should be the goal for next years to allow the visualization research and content distribution system move ahead. There are already some 4K national initiatives in Europe, that may support the research on 4K and higher resolutions. Nonetheless, there is a need of further international collaboration and growth of the pan-European infrastructure. This ambitious challenge should be definitely treated as high priority task in order to allow further development of new media technologies.

Keywords
new generation media, high resolution, 4K, future networks, scientific visualization, R&D

Introduction
The development of visualization technologies from one side and requirements of research and industrial communities from the other, cause the consecutive growth of the resolution of video displays. Nowadays, when the High Definition technology becomes the leading resolution technology in the world, for many areas of the science, market and entertainment it is still to low. The forthcoming technology beyond HD, often called 4K or Ultra High Definition (UHD), is very demanding for both networks and storage.

However, now the main usage of the technology is still digital cinema and broadcasting, there is a strong need of building integrated and distributed environment for high resolution applications from the research community. This article will present the 4K technology, its possible applications as well as the necessity of building the pan-European infrastructure for high resolution scientific visualization.

Technology
In simple words, the 4K is the resolution of 8-9 MPix having about 4 thousands points horizontally. The resolution often depends on the screen aspect ratio, but the most common resolutions are DCI (Digital Cinema Initiatives [1]) compliant which is 4096x2160 and Quad HD which is 3840x2160. In general the „4K” term states also for the technology capable of recording, processing and displaying the 4K resolution.

The 4K is also very demanding technology for both devices and software processing. Single uncompressed DCI compliant 4K frame takes about 40 MBytes of disk space¹. Multiplying it by 24 such frames per one second, the disk space required for storing just one second of 4K video is about

¹ Such calculations base on DCI requirements for 4K which describes resolution of 4096x2160, RGB, 4:4:4 (no chroma subsampling) and 12 bits per channel (36 bits per each single pixel)
1 GByte, and 3.4 TBytes for one hour. It affects also network interfaces required for transmission of high resolution videos. In the live uncompressed 4K transmission, which takes about 7 Gbit/s, there is need of using 10 GbE network interface or at least use several 1GbE in parallel. For stereoscopy purposes those number may be doubled if transmitting two consequent streams for both eyes. The compression algorithm defined by DCI and used for encoding 4K is JPEG2000. JPEG2000 basing on discrete wavelet transform (DWT), guarantees very good picture quality in limited bandwidth. The maximal video stream should be limited to 250 Mbit/s and any single frame can't take more than 1,3 MBytes. So, even compressed video is quite demanding, especially in case of multiple parallel streams, what certainly is the typical use case for broadcasting studios and digital repositories with streaming capabilities, and even more important in scientific visualizations which often go beyond standard use. Addressing such requirements is a subject of various projects, e.g. HPDMNet which concentrates on designing, developing and implementing the world's first international high performance service specifically created for high quality, large-scale digital media, including support for extremely high volume media streams [2].

Applications

The requirement of 4K and higher resolutions is very common in the industry and science. The largest application is still the digital cinema. Apart from typical advantages of digital broadcasting and higher resolution, the live movie streaming can be a chance for smaller cinemas or venues, especially in small towns. Nowadays they must often wait a long time for the copy of new movie. Using digital streaming of high resolution video over high speed network, they will be able to get the movie immediately with selected quality, bit-rate and resolution. Moreover, such a solution will increase distribution security, since video on demand distribution model will exclude multiple playbacks without adequate charge. There is also a place for different streaming sources such as transmitting mass events, concerts or sport competitions. The example architecture of such content distribution system is depicted on Fig.2

However the DCI defines standards only for digital cinema, the 4K is not limited to cinema entertainment. The 4K is often used in computer aided design (CAD) and visualization in such segments as architecture and urban planning, automotive design or security and monitoring of large halls, venues or airports.

High resolutions are also used or required for scientific purposes. The technology is implemented in development and visualization of scientific processes related to elementary particles, quantum
mechanics, genetics structures, weather and climate simulations or astronomy and radio-astronomy. Live streaming of the best resolution video with very good quality is often required in tele-medicine while recording and transmitting medical surgeries or diagnostic processes to remote team of specialists. Moreover, the medical utilization of the technology often requires uncompressed video due to patient safety what causes streaming more demanding.

Very interesting implementation of high resolution is a combination of tele-presence, scientific rendering and remote collaboration using visualization frameworks based on cluster solutions with tiled displays. The example of such systems may be SAGE library [3] or CGLX [4] visualization framework which have many implementations around the world, also in Europe.

**Collaboration for scientific visualization**

However the 4K technology is new and there are still very few devices capable to process or display such resolution, some universities and research centers are already working on development and popularization. There is the initiative called CineGrid which resides in California and has been established to promote research, development and deployment of new distributed applications of ultra-high performance digital media (sound and picture) over advanced networks, using Grid computing technologies for networked collaboration [5]. In order to show that the 4K transmission and workflow is already possible, there were some streaming demonstrations took place under patronage of CineGrid [6]. The intercontinental transmission engaged mostly Japan, U.S. and some European countries [7]. Similar initiatives also take place in Europe. Some universities and research centers have already established their 4K nodes and been supporting national new media initiatives as well as international cooperation. In November 2009 two European organizations – University of Essex and Poznan Supercomputing and Networking Center launched the first European transmission between Poznan and Colchester using JPEG2000 compression. It was the first DCI compliant JPEG2000 [8] RTP transmission in the GEANT network. Streaming devices, which were used during the transmission, were provided by European vendor.

Since the advanced visualization systems becomes reality, there is strong need to develop advanced distributed infrastructure in Europe. Crucial systems for transmitting and storing high resolution video content have to evolve. The necessity of escalating research on high resolution video appears to be extremely important for supporting and developing new technologies. Common European initiative would support international research and development and would make accurate partnership and cooperation possible. One of the most important activity research nowadays is the visualization of scientific processes, which cause the demand for video quality improvements. To achieve that goal, the growth of the display resolution is the necessity. However, higher resolutions require more resources for processing, transferring and displaying the content. Many current or planned research projects focus on development of new visualization possibilities, including higher resolutions or stereoscopy. In order to make it possible, an intensive research and deployment in many various areas are needed.

Future networks will concentrate on deploying complex services for both industry and research. As mentioned before, the requirements of network bandwidth for demanding visualization applications may be very high, but the development of network technologies seems to satisfy those needs in near future. The most important challenge besides the network capability will certainly be combining various services in a common layered system. Networking layer will require higher bandwidth and reliability for deployment complex services organized in Computing layer. That layer will contain distributed grids and cloud computing resources operating on scientific data. That data, generated by various projects and initiatives, is often collected in digital libraries and may be used by Visualization layer, which is operating on high resolution devices. The hierarchy of layered system was depicted on Fig.1.
Although the 4K is new, it may be not enough for many applications. There are already some prototype devices working in 8K resolution which requires 4 times more disk space, processing power and network bandwidth than the 4K [9]. Regarding 8K stereoscopy, the required bandwidth for uncompressed video may reach almost 50 Gbit/s. It shows how fast the network must be in near future. The high resolution video applications will certainly be one of the reasons for further network growth.

References

Biographies

Artur Binczewski received the M.Sc. degree in Computer Science from the Poznan University of Technology in 1993. He is the Manager of Network Division at the PSNC. He was involved in several EC projects: SEQUIN, ATRIUM, 6NET, GEANT. He coordinates the Porta Optica Study and PHOSPHORUS projects. He is author or co-author of papers in major professional journals and conference proceedings.

Maciej Glowiak graduated from Poznan University of Technology in 2003, then he started working for the Network Department of Poznan Supercomputing and Networking Center. Glowiak’s technical background is network software engineering and parallel computing. His professional research interests include high-capacity networks, network monitoring, new protocols (IPv6), new multimedia technology research, HD/4K video hardware and software development, among other areas. He is involved in many Polish and European networking projects such as 6NET, GEANT, PIONIER, Platon. He works on building 4K node in Poland and multimedia streaming. Maciej’s programming skills are mostly Java, C/C++ and PHP. He is also experienced in database solutions such as MySQL and PostgreSQL.

Bartlomiej Idzikowski graduated from the Poznan University of Technology in 2003 and received the M. Sc. degree in Computing Science - Computer Networks and Distributed Systems (Master's thesis: "Application for management of CISCO educational networks"). His research interests focus on videoconferencing (educonf in GN2, Videoconferencing Service in Pionier network), high resolution video systems (4K node in PSNC), web-based applications, streaming technologies, network management and traffic monitoring. Bartlomiej is member of 4K team in PSNC, which has created first 4K node in Poland. His other fields of interests are streaming protocols (RTP, RTSP), streaming servers, database management and administration, software engineering, web services, unix-like systems and XML technologies.

Dr. Maciej Stroinski received the Ph.D. degree in Computer Science from the Technical University of Gdansk in 1987. Currently he is Technical Director of the PSNC. He is also lecturer in the Institute of Computing Science of the Poznan University of Technology. His research interests concern computer network protocols and management. He is author or co-author of over 100 papers in major professional journals and conference proceedings.

Maciej Strozyk received the M.Sc. degree in Computing Science (specialization: Computer Networks and Distributed Systems) from the Poznan University of Technology in 2003 (Master's Thesis: “Optical networks management”). Since 2003 he has been working as system designer/analyst and programmer for Network Department of Poznan Supercomputing and Networking Center (PSNC). He was involved in several projects: 6NET, PHOSPORUS, GEANT, Mupbed, Clusterix, Platon. Among other activities he also builds Polish 4K node.