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Global university system for engineering education in the age of globalization

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The Global University System (GUS) is a world wide initiative to create an advanced telecommunications infrastructure for access to educational resources across national and cultural boundaries in the search for global peace. GUS aims to create a world wide consortium of universities to provide the underdeveloped world with access to 21st century education via broadband Internet technologies. The aim is to achieve 'education and healthcare for all', anywhere, anytime and at any pace. GUS works in the major regions of the world in partnership with higher education and healthcare institutions. Learners in these regions will be able to take their courses from member institutions around the world to receive a GUS degree. These learners and their professors from partner institutions will also form a global forum for exchange of ideas and information and for conducting collaborative research and development with the emerging global GRID computer network technology. The Globally Collaborative Innovation Network (GCIN) with a globally distributed computer simulation system will foster the creativity of youngsters around the world. The Globally Collaborative Environmental Peace Gaming (GCEPG) Project will be its most powerful demonstration. GUS will be available to game players around the world.

Keywords: Global education; GRID; Globally distributed computer simulation; Globally collaborative environmental peace gaming and innovation network

1. Background

Economic interdependence among nations and cultures is spawning a global economy. Globalization also highlights clashes of divergent cultures and belief systems, both political and religious. If global peace is ever to be achieved, global scale education, with the use of modern digital telecommunications, will be needed to create mutual understanding among nations, cultures, ethnic groups and religions. The Internet is the future of telecommunications, and can be a medium for building peace.

The Global University System (GUS) has a long history of concept development and testing of multiple hardware configurations suitable for remote Internet access. These initial steps are summarized in our recent book, *Global Peace Through the Global University System* (Varis

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et al. 2003). The purpose of this book is to internationally make known the philosophy, past and present actions, as well as future plans, of the GUS, which have resulted from years of development and a seminal working conference at the University of Tampere, Finland, in 1999, with funds from the World Bank, the US National Science Foundation and others.

The editors' paper in the book, 'Creating global university system' (Utsumi *et al.* 2003) emphasizes the important role of higher educational institutions, not only as the knowledge centres of their community in the eradication of poverty and isolation, but also as a gateway to the world for collaboration in creating new knowledge in a global knowledge society of the 21st century. This paper summarizes the accomplishments of GUS and shows that GUS is poised to begin implementation of broadband Internet access and academic programmes in remote areas of the world.

2. Global University System

GUS is a world wide initiative to create a satellite/wireless telecommunications infrastructure and educational programmes for access to educational resources across national and cultural boundaries for global peace. GUS aims to build a higher level of humanity with mutual understanding across national and cultural boundaries for global peace. GUS helps higher educational institutions in remote/rural areas of developing countries to deploy broadband Internet in order for them to close the digital divide. Education and job skills are the keys in determining a nation's wealth and influence.

GUS has task forces working in the major regions of the globe with partnerships between higher education and healthcare institutions. Learners in these regions will be able to take their courses, via advanced broadband Internet, from member institutions around the world to receive a GUS degree. These learners and their professors from participating institutions will form a global forum for exchange of ideas and information and for conducting collaborative research and development with emerging global GRID computer network technology.

2.1 *Proposed infrastructure*

As shown in figure 1, GUS programs and services will be delivered via regional satellite hubs, typically located at a major university, that connect via high speed satellite (∼45 Mbps) to educational resource cites in the EU, USA and Japan. In a sense, the regional satellite hub is to be the major Internet Service Provider (ISP) for not-for-profit organizations in the region and the gateway to the outside world. The major university may also be connected to very high speed broadband Internet, similar to the optical fibre network at 3 Gbps of the Multimedia Broadband Internet (MBI) of the Ethiopian government.

Regional hubs link to branch campuses or other regional educational institutions via microwave (∼45 Mbps) over relatively short distances (25–50 miles). Communication from the hub and branch campuses to local sites, over distances up to 10 miles, will be by spread-spectrum wireless (∼2–10 Mbps) Internet networks, which do not require licenses in most countries.

Those buildings with a broadband Internet connection will then also become relay points for the low cost 'Wi-Fi' (wireless fidelity) networks at 10 Mbps that are now rapidly appearing in Japan, USA and Europe. This advanced wireless communication with laptop computers will make e-learning possible for anyone, anywhere and anytime, with the capability for Internet telephony, fax, voice mail, e-mail, Web access, videoconferencing, etc. This will not only help local community development, but also ensure close cooperation between the higher, middle and lower levels of education.

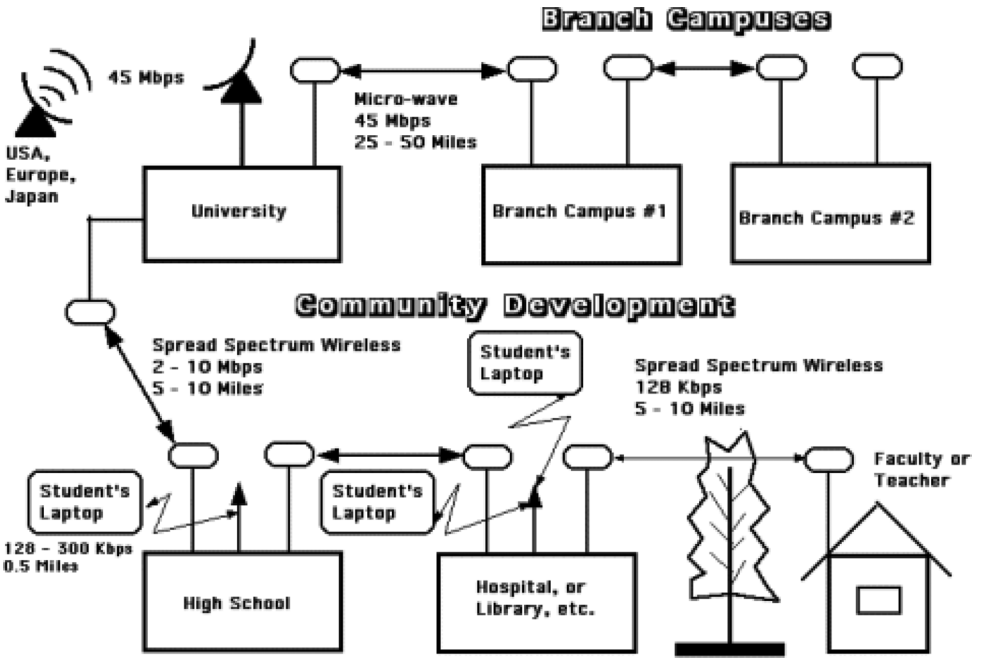

Figure 1. Global broadband wireless and satellite internet virtual private network.

2.2 *Current GUS projects*

The major university will then connect to secondary and elementary schools, libraries, hospitals, local government offices, NGOs, etc., with broadband wireless Internet at drastically discounted rates or free of charge. GUS projects are now starting in Ethiopia, Nigeria and Malawi in Africa and Cambodia in Asia and have inquiries have been received for the same from others.

2.3 *Organization*

GUS has its headquarters at the Global E-learning Center at the University of Tampere in Finland, under the direction of the UNESCO/UNITWIN Networking Chair, held by Dr Tapio Varis. Currently, institutions with faculty members who are participating in GUS development projects are numerous in various countries. GUS will serve as an educational broker for universities, thus helping them gain international influence and access to students that they would not otherwise reach. Those institutions affiliated to GUS become members of the GUS/UNESCO/UNITWIN Networking Chair Program.

3. Future direction of engineering education

The trends of the 21st century are: (1) a shift of technology from analog to digital (e.g. slide rule to digital computer, circuit switching telephony to packet switching digital telecommunication); (2) the globalization of society, commerce and culture; (3) the emergence of a new knowledge/creative economy out of a manufacturing industrial structure.

Engineering is the realization of innovation, which is the commercial application of invention, which is based on creativity, which is the essence of the 'knowledge economy society' of the 21st century. In the age of globalization creativity ought to be made collaboratively on a global scale, which in turn brings about mutual understanding among the young and, hence, global peace. Attaining global peace ought to be the utmost aim of education, rather than the mere enhancement of job skills, as conventional education does.

Bearing this in mind, the following are my suggestion to the reader as to the future direction of engineering education, based on an engineering career half a century: creating the Summer Computer Simulation Conference in the early 1970s; pioneering work on the analysis of chemical reactions by computer simulation (late 1950s to early 1960s); the creation of process control simulation systems for petrochemical plants (in late 1960s); the extension of ARPANET and its commercial network version to various countries (predecessors of the Internet) (in 1970s to early 1980s); initiation of the concept of GRID networking technology (early 1970s); global gaming simulation (mid 1980s) and multipoint-to-multipoint, multimedia, interactive videoconferencing with hybrid technologies spanning the globe (mid 1980s to present).

Computer simulation and its successor, virtual reality/virtual laboratories, are at the forefront of scientific and engineering research and development to create new knowledge. It has successfully replaced hardware oriented experiments, e.g. the design of aircraft, architecture, bridges, chemical plants, automobile crash testing and even the design of pharmaceutical molecules. With the advent of broadband Internet around the globe (e.g. GLORIAD; Cole 2005) and GRID networking technology such research and development can now be conducted in distributed computer simulation mode on a global scale as aggregating creativity of youngsters around the world.

3.1 *Creativity and innovation*

Creativity is the province of *Homo sapiens*. We live for the future, not in the past. Science and technology open up the future. However, the application of new technology often meets with 'creative destruction'—the famous words of Joseph Schumpeter. Flora and fauna have to break their shell to have a new life. We need not only to foster the creative capabilities of the young, but also help them break out of their shells. 'The biggest barrier for new development of Human-Centric Knowledge Society is our Industrial Age mindset!' (Kautto-Koivula and Huhtaniemi 2003). The industrial age was based on tangible matters, the moral of which was obedience, e.g. Taylor's 'time and motion study' as an extreme example. The raw materials of the knowledge economy are intangibles, creativity and innovation, for which there is no economic theory.

3.2 *The culture of America (a unique crucible for innovation)*

The American culture is particularly suited to the creative mind. America is a much more innovative place than any other country. America allows you to explore your mind. America is the greatest engine of innovation that has ever existed and it cannot be duplicated anytime soon, because it is the product of a multitude of factors (Friedman 2004):

- freedom of thought;
- an emphasis on independent thinking;
- a steady immigration of new minds;
- a risk-taking culture with no stigma attached to trying and failing;
- a non-corrupt bureaucracy;

- financial markets and a venture capital system that are unrivaled at taking new ideas and turning them into global products.

These institutions, which nurture innovation, are the real crown jewels of American culture. The whole process whereby people get an idea and put together a team, raise the capital, create a product and mainstream it can only be done in the USA. US technological workers must keep creating leading edge technologies that make their companies more productive, especially innovations that spark entirely new markets. This is America's real edge.

An innovation economy demands that society be open, dynamic, educated, international and risk-taking. Given the chance, innovation can improve all our lives. Financial risk-taking is the fuel that powers the process of change. World wide innovation networks are the new keys to research and development vitality and competitiveness. Such networks (broadband, 24/7, wired and wireless) in the knowledge economy society of the 21st century would nurture the 'connected community' and build collaboration to provide the kind of leadership that the digital age requires and, above all else, begin promoting the process of enhancing, encouraging and fostering creativity and innovation in all its forms—in the school, in the workplace and throughout the community (Eger 2005).

We are now in the early stages of a new era, the 'creative age', in which creativity and innovation will be the hallmarks of the most successful communities and vibrant economies. This age will thrive and prosper if communities tolerate dissent, have respect for individual enterprise and freedom of expression and recognize that innovation is the driving force of the new knowledge economy, not mass production of low value goods and services.

At a time of intense division, with deep political and religious fault lines splitting the world, innovation stands out as a powerful integrative force. It ties countries, companies and consumers together in creating value, solving problems and generating wealth (*Business Week* 2004).

3.3 *GRID technology*

GRID technology enables the sharing, exchange, discovery and aggregation of resources (processors, storage, scientific devices, information, knowledge, etc.) across geographically distributed sites. Many now consider GRID technology as the next generation Internet, a concept I initiated in 1972 (McLeod 2000). It has demonstrated necessary effectiveness in the scientific domain to become the de facto e-science technology infrastructure. This technology promises to do what the Internet has done for data for applications. GRID computing extends the scope of distributed computing to encompass large-scale resource sharing, including massive data storage, high performance networking and powerful computers and highly expansive equipment (i.e. microscopes, telescopes, 3D Cave). GRID technology defines a new powerful computing paradigm analogous to the electric power grid. Users of the GRID will then be able to: (a) use his/her private workplace to invoke any application from a remote system; (b) use the best suited system to execute their desired particular application; (c) access data securely and consistently from remote sites; (d) exploit multiple systems to complete complex tasks in an economical manner; (e) use multiple systems to solve large problems that exceed the capacity of a single one. In this vision sharing doesn't mean simple exchange of data or files, but rather a concrete access to resources (e.g. computers, software, data, etc.).

GRID technology has great potential in education, offering a framework that opens up new ways of teaching and learning that have not been possible before. E-mail and multimedia web sites have so far significantly contributed to society in the dissemination of information. The next phase of Internet development with global GRID computer networks should be globally collaborative experiential (so-called 'hands-on') learning and the constructive creation of

wisdom with interactive actions on virtual reality simulation models of joint global research and development projects in various subjects. It has been said 'Knowledge applied with interaction becomes Wisdom'. Globally collaborative experiential learning via broadband Internet across national, continental and oceanic boundarie would realize such wisdom creation. The principle of 21st century education should be inheriting wisdom more than the mere transfer of knowledge.

3.4 *Globally Collaborative Environmental Peace Gaming (GCEPG)*

GCEPG (Utsumi 2003) on a globally distributed computer simulation system, focusing on the issue of the environment and sustainable development in developing countries, can be used to train would-be decision-makers in crisis management, conflict resolution and negotiation techniques based on 'facts and figures'. GUS will supply game players, simulationists and technical support from around the world. With global GRID computer networking technology and Beowulf mini-supercomputers using cluster computing technology we plan to develop a socio-economic environmental simulation system and a climate simulation system in parallel, both of which will be interconnected on a global scale (see figure 2).

GCEPG with a globally distributed computer simulation system is a computerized gaming/simulation to help decision-makers construct a globally distributed decision support system for positive sum/win–win alternatives to conflict and war. The idea involves interconnecting experts in many countries via the Internet to collaborate in the discovery of new solutions to world crises, such as the deteriorating global environment, and to explore new alternatives for a world order capable of addressing the problems and opportunities of an interdependent globe. Gaming/simulation is the best tool we have for understanding the world's interwoven problems and the solutions we propose for them. Systems analysis for systemic change at the global level is a precondition for any significant resolution of today's global scale problems. The understanding gained by scientific and rational analysis and critical thinking based on 'facts and figures' would be the basis of conflict resolution for world peace and, hence, ought to provide the basic principles of global education for peace.

The purpose of an interactive gaming mechanism is to help find appropriate alternative policies by establishing consensus among participating parties. It is suggested here that globally distributed computer simulation should be tested interactively with the game player inserting pseudo-policy parameters into the models whenever necessary during execution of the simulation. This is called peace gaming/simulation (Utsumi 1977), similar to war games practiced by military strategists (Schram *et al.* 1971). With the advent of global broadband Internet access and standard interface protocols for interconnecting various dispersed, dissimilar host computers the potential exists to ensure the coordination of international efforts by providing more frequent communications and an environment for shared development, enabling more credible simulation studies than was previously possible.

3.5 *Globally collaborative experiential learning with the European Learning GRID Infrastructure (ELeGI)*

The ELeGI Project (Allison *et al.* 2003), which is now funded by the European Commission, aims to design and implement advanced service-oriented GRID-based software for learning. This project, involving 23 prominent educational and industrial organizations in Europe, will develop a new paradigm focused on knowledge construction using experiential and collaborative learning approaches in a contextualized, personalized and ubiquitous way. This will

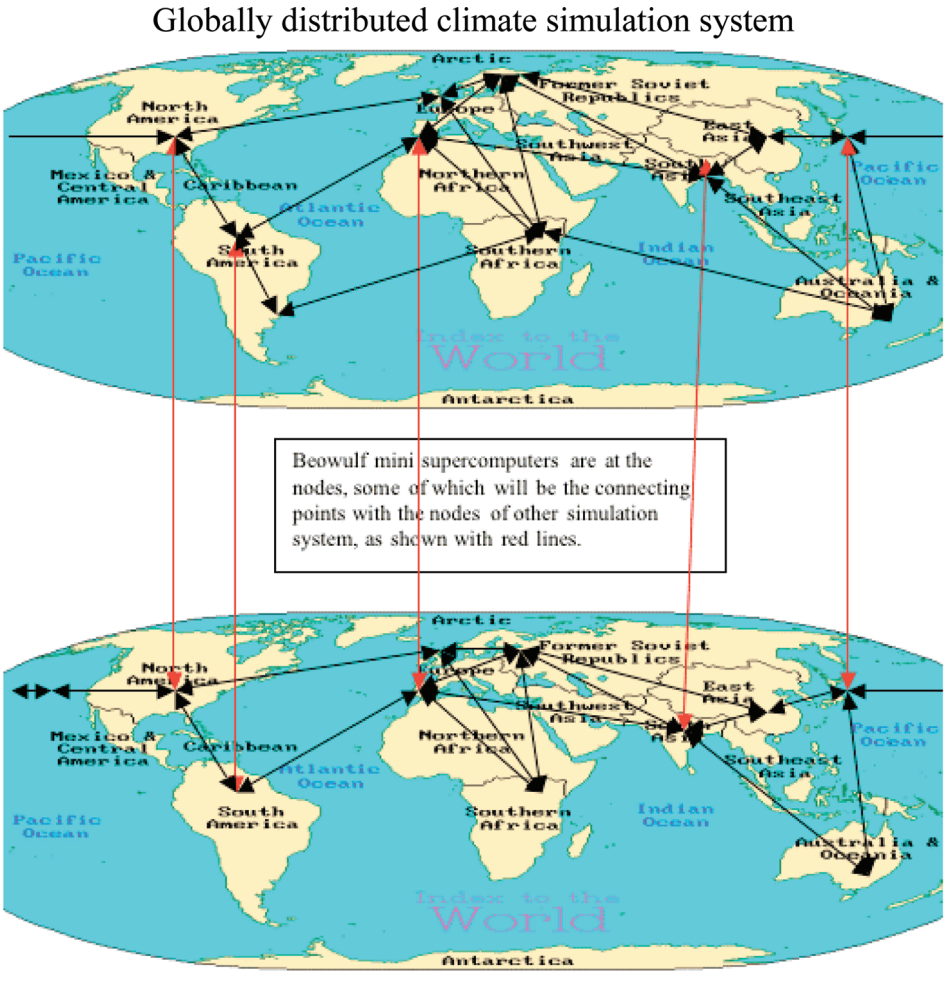

Figure 2. Globally collaborative environmental peace gaming networks.

replace the current information transfer paradigm, which is based on content and on the key authoritative figure of the teacher, who provides information.

The GCEPG Project could be a complete and powerful demonstrator of the ELeGI Project to show: (1) the advantages arising from the use of advanced technologies (i.e. GRID to access computing resources and collaborative environments) to support simulation execution, data analysis, etc.; (2) simulations for learning through the definition of innovative pedagogical models (i.e. a socio-constructivist contextualized learning approach); (3) the benefits arising from the harmonized and synergistic use of advanced technologies together with innovative pedagogical models for learning (i.e. ELeGI).

Cooperation with the ELeGI Project will ensure the development of globally collaborative, experiential, distributed learning on globally distributed simulation systems for joint research and development on various subjects by people around the world. This will foster their creativity and, hence, promote mutual understanding among them. Also, as Senator Fulbright once said: ‘Learning together and working together are the first steps towards global peace’.

3.6 *The Globally Collaborative Innovation Network (GCIN)*

Spreading the culture of a creative and innovative society can only be done by education, and this is a much better, more effective and peaceful way of spreading democracy than using weapons! Thanks to the advent of global broadband Internet access and GRID networking technology this can now be done more readily than before, and more so in a globally collaborative fashion. The Globally Collaborative Innovation Network (GCIN) with a globally distributed computer simulation system will foster the creativity of the young around the world. The GCEPG Project will be a powerful demonstration.

The principle of packet-switching technology (the basis of the Internet) is 'sharing', to drastically reduce the cost of expensive high-speed telecom lines. With the creation of GUS we are extending this principle to the sharing of knowledge and even wisdom. The principle of GRID networking technology is 'collaboration'. Those two principles of sharing and collaboration are the very bases of attaining global peace, which ought to be the ultimate aim of education, rather than mere enhancement of job skills, as in conventional educational institutions around the world. We hope to attain global peace by expanding use of the Internet and GRID technologies around the world with e-learning and e-healthcare/telemedicine.

The growth of advanced economies is driven largely by knowledge workers, such as scientists, engineers, managers, professionals and artists. We now need to train the youth of the world to become world class knowledge workers with global e-learning and create an environment in which they can collaborate with the use of advanced information and communication technologies (ICTs) and GRID networking technology. This is because the entire global economy increasingly revolves around innovations that flow from the creative classes.

4. Expected benefits

With the rapid advancement of computer simulations using GRID networking technology, such a network of mini-supercomputers around the world can also be used by researchers, even in developing countries, to interact with their counterparts in developed countries in joint collaborative research in virtual realities and virtual laboratories covering various academic and engineering subjects. They can also be used in high energy, nuclear and fusion energy physics, atmospheric science, geological science (Cole 2005), microbiology, molecular studies, human genomics, DNA analysis, medicine/bioscience, telemedicine, commerce, nanotechnology, joint advanced engineering design, etc. (Sterling 2001).

In a sense, our GUS/UNESCO/UNITWIN Networking Chair Project aims to construct global scale knowledge forums with advanced ICTs, i.e. with the use of massive parallel processors of globally distributed and yet interconnected mini-supercomputers through a global GRID computer network. This will be a paradigm shift in research and development on a global scale, out of the so-called isolated, academic 'Ivory Tower' approach.

5. Financing GUS and GCIN

GUS projects will combine (1) Japanese government's Official Development Assistance (ODA) funds and (2) Japanese electronic equipment with (a) Internet technology and (b) the content development of North America and Europe.

6. Conclusions

The GUS programme is a comprehensive and holistic approach to building smart and creative communities (Eger 2003a, b) in developing countries for e-learning and e-healthcare/telemedicine. Initiatives are under way to create the necessary infrastructure and educational liaisons, and some near-term educational access is expected.

GUS and GCEPG are clearly ambitious programmes that cannot be achieved by any one group, university or national government. The programmes require substantial collaborative contributions of ideas, expertise, technological resources and funds from multiple sources. Those who value the visions of GUS and GCEPG are invited to join this great and noble enterprise.

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