

## Developing Countries Access to Scientific Knowledge

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### Abstract

CERN is an International Organisation supported by twenty European member states. It conducts research into high energy particle physics. This requires very large particle accelerators and large experiments where particles are collided and the effects studied. At the moment CERN is constructing the Large Hadron Collider, LHC, and four large experiments ALICE, ATLAS, CMS and LHCb. The funds for constructing the LHC come from the European member states, USA, Russia, Japan, Canada and India. There are contributions from these countries and many others to the cost of the experiments. In 2007, when the experiments start running, there will be an enormous demand for computing which has lead CERN to study GRID computing. The large size of these collaborations, up to 2000 scientists, allows people from weaker countries to join with those from stronger regions. Czechoslovakia, India, Pakistan, Russia and Taipei are examples of countries actively participating in setting up their own GRID centres. The CMS experiment where I am computing resource manager has had particular success working with Pakistan. Arshad Ali, head of computing at the Computing institute of the National University of Science and Technology, will report on the benefits as seen from the Pakistani side.

### Introduction

CERN [1] is the European Laboratory for conducting large high energy physics experiments. The European member states pay for the infrastructure which has been built up over the last fifty years around a series of powerful particle accelerators. Experiments are conducted at CERN and consist of very large collaborations of institutes from the technologically developed countries of the world. There are twenty member states: Austria, Belgium, Bulgaria, Czech FR, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovak FR, Spain, Sweden, Switzerland and the United Kingdom. The major contributors are France, Germany, Italy and the United Kingdom. The poorest member states are those which have recently joined from the former communist block.

CERN sits on the border between France and Switzerland near Geneva and these countries have a special role as hosts. The largest accelerator forms a circle of about 27 kilometres and is underground inside a tunnel. The experiments are constructed in large halls far underground where twin particle beams are collided. The debris from the collision is tracked electronically using a large number of channels. This raw data is stored on the computers and the work begins of reconstructing this raw data into physics events. The data is then distributed to the participating institutes for detailed analysis. It is this last process that will extensively use GRID computing [2].

### Material Contributions to the LHC Accelerator and its Experiments

We are currently constructing the Large Hadron Collider, LHC [3]. The funds come from the member states listed above and some non-member states, in order of their contribution size, USA, Japan, Russia, Canada and India. The latter group contributes about 0.6 Billion Swiss Francs out of the total 4 billion required to build the accelerator. India has committed to pay \$25 million. Novosibirsk, Russia, has supplied the LHC dipole magnets and India has supplied corrector magnets – technologies that are now both well advanced in those countries.

There are four major LHC experiments [4], two general purpose ones ATLAS and CMS searching for the Higgs boson and the hypothesised SUSY particles, while ALICE will study the Quark Gluon Plasma and LHCb will study matter and anti-matter asymmetries. Each experiment is large with CMS [5] weighing in at an amazing 12,500 tons. Pakistan has supplied the large supporting feet on which the experiment sits as well as some advanced electronics and lasers. Russia has manufactured the lead tungstate crystals which are 98% metal by mass but are completely transparent. Other developing countries participating in CMS are Armenia, Belarus, Brazil, Bulgaria, China, Croatia, Estonia, Georgia, Hungary, India, Iran, Korea, Pakistan, Poland, Russia, Serbia, Slovak Republic, Taiwan, Turkey, Ukraine and Uzbekistan..

### The Computing Challenge and the GRID

The LHC experiments which will start generating data in 2007 will require new levels of data acquisition, new levels of event complexity, and enormous quantities of data that will be accessed by institutions worldwide. The CMS experiment will generate one petabyte of experimental data per year. This must be processed and analysed in the search for new phenomenon. CERN as the host to the experiments will need computing capacity which is far greater than that covered by Moore's law which is some measure of the capacity that technological advances provide for a constant number of processors or investment.

CERN will therefore try to supplement its own large investment by involving directly the outside institutes in the analysis of this vast amount of data. The GRID technology tackles this problem providing distributed computing over the wide area networks, high throughput computing centres, on-demand computing, optimisations for data intensive processing and support for collaborative computing. CERN's network to the world connects 267 institutes in Europe and 208 institutes elsewhere providing access to over 6'000 scientists. This development is already underway with tools in place and CMS starting to exercising the GRID with 13 groups of institutes involving 30 institutions. Monitoring tools watch progress in these centres and display their results on a worldwide map.

### Centres participating in the LHC Computing GRID

It is probably clear by now that CERN is a very open club with access not restricted to member state countries only. Experiments running at CERN are based on very large collaborations numbering up to 2,000 scientists. This is quite a change from the early days of CERN when a group of 50 was considered large. The large experiments allow people from economically weaker countries to join with those from stronger regions. Proposals to join experiments are judged on their merit and no one looks at the passports of the people making them but, in general, CERN expects people who have not funded the laboratory infrastructure to contribute more than their proportional share to the cost of the experiment. These contributions can take many forms, such as assembly effort, electronics and control system software. The main criteria are that both sides gain from the total experience.

The LHC Computing GRID project [6] was set up so that major computing centres involved in the experiments could coordinate their activities. At the centre sits CERN as the host laboratory computing facility and this is where the data undergoes its first reconstruction so that some physics may be extracted from the signals coming from the

vast number of data channels. The next tier consists of regional centres which are large computing centres that serve a large number of physicists in many institutes. At present they are based in the USA (Brookhaven and Fermilab), Italy, Germany, France, the United Kingdom, Japan and also CERN. Other less powerful centres will be in Taiwan, Spain, USA, Germany, Italy, Switzerland, Russia, Pakistan, the Netherlands, Sweden, India, Canada, and the Czech FR.

### The Example of Pakistan

Pakistan is now building up a high energy physics community that will participate in the CMS experiment. In fact there are people who could not attend this round table since there is a GRID technology workshop taking place in Islamabad. After a day of introductory talks the students are learning how to use the GRID with computers already installed so that the students get hands on experience. This workshop has been organised by CERN and the Pakistani National Centre of Physics (NCP), with a lot of help from the National University of Science and Technology (NUST) and some selected people from the Pakistani Atomic Energy Commission. The course will be given by CERN experts, Heinz Stockinger and Flavia Donno, who have themselves participated in the GRID development.

The GRID now operates from CERN to NCP and NUST, and is already being used to generate data that simulates the operation of the CMS experiment. The experience shows that these centres can be used effectively to do computer intensive tasks where processing power is needed but networking requirements are less strong. We have however already made great advances on the networking front with video conferencing now taking place between CERN and Pakistan on a regular basis. This has been promoted by Harvey Newman's group in Caltech, USA, a member of CMS. But it is essential that these centres spend resources on networking before building impressive computer centres containing large amounts of computing power.

Arshad Ali from NUST will give a paper at this round table showing the benefits of this collaboration to Pakistan. He has developed strong ties with CERN, Caltech and the University of the West of England, UWE. This has resulted in a number of investments in terms of equipment and people of the order of \$200,000. Recently UWE and NUST received a grant from the European Union Asia Link initiative to develop a joint research programme in which faculty from NUST receive advanced training within this joint programme. This Asia Link initiative valued at about 400,000€ also includes the University of Savoie in France and the Beijing Institute of Technology in China.

Recent individual successes involve Asif Osman from Pinstech who has been working in CERN collaborating with Mehnaz Hafeez and Kamran Munir to install CMS production on their centres and to set up the GRID computing for the workshop. Waseem Hassan has just been awarded his M.Phil. from the UWE. Saima Iqbal, from Karachi University, until recently supported by Caltech to work at CERN is now doing her master's course work in UWE. Asif Jan and Ashiq Anjum from NUST are both working on projects supported by CERN and Caltech. All of this has been made possible by the tireless efforts of Arshad Ali who has worked incredibly hard to build up these relationships.

Here it is appropriate to mention an aspect of Arshad Ali's work which has proved essential. He has spent much effort to involve the higher levels of his university's

management, the ministry of science and even to bring this to the notice of the president himself. The rector of NUST, Syed Shujaat Hussain, visited CERN two years ago and will now visit Caltech. Harvey Newman from Caltech and Dieter Blechschmidt from CERN have written a number of letters to the Pakistani government explaining the benefits and successes of this collaboration. Memoranda of Understanding have been signed. CERN has a department supporting the VIP visits to CERN, many of our directors travel to developing countries signing agreements and finally many of our scientists from experimental collaborations participate in conferences and workshops worldwide.

## Conclusions

For CERN the scientific goals of the organisation are of the highest importance. The research requires technological advances that are of value to all. The foundations lie in a network of competent institutes worldwide. The facilities of CERN are made open to everyone in the scientific community and consequently the research results are published. CERN has a history of successful worldwide international collaborations during its almost 50 years. In 1954 Europe consisted of nations that had recently fought one of the most destructive wars in history and was entering a period of the cold war with the Soviet block. Since that time CERN has always been a fine example of how scientists from all over the world can work together.

## References

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