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ScienceScope

PUBLICATION OF THE CSIR | VOLUME 5 | NUMBER 2 | MAY 2011
SOUTH AFRICA'S COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Information and communications technology

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our future through science

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In 1948, Claude Shannon, a young engineer and mathematician, published '*A Mathematical Theory of Communication*'. With this landmark paper, Shannon laid the foundation for information theory.

ON 30 JUNE in the same year, Bell Labs unveiled the invention of the transistor by Bardeen and Brattain, discovered almost accidentally during experiments aimed at understanding the behaviour of electrons at the interface between a metal and a semiconductor and why the 'field effect' semiconductor amplifier proposed by Shokley did not work.

In the 1956 award ceremony speech for the Nobel Prize in Physics, their achievement was described thus: "Doctor Shockley, Doctor Bardeen and Doctor Brattain. The summit of Everest was reached by a small party of ardent climbers. Working from an advance base, they succeeded. More than a generation of mountaineers had toiled to establish that base. Your assault on the semiconductor problem was likewise launched from a high-altitude camp, contributed by many scientists. Yours, too, was a supreme effort – of foresight, ingenuity and perseverance, exercised individually and as a team. Surely, supreme joy befalls the man to whom those breathtaking vistas from the summit unfold. You must have felt it, overwhelmingly. This joy is now shared by those who laboured at the base. Shared, too, is the challenge of untrodden territory, now seen for the first time, calling for a new scientific attack."

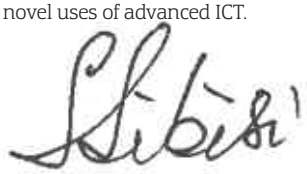
Shannon's work on information theory has subsequently had significant implication in engineering and computer science. The invention of the transistor eventually led to digital electronics enabling the modern field of information and communication technology or ICT from the convergence of the previously separate fields of telecommunication and information technology. Other milestones on the road to the now nearly ubiquitous ICT, from twitter and facebook revolutions to iPads, include the development of integrated circuit technology (Jack Kilby, 1958), Ethernet (Robert Metcalfe, 1976), the Internet protocol (Vint Cerf and Bob Kahn, 1974), optic fibre (Charles Kuen Kao and other between 1966 and 1975 when the first non-experimental fibre-optic link was installed by the Dorset, UK police), GSM mobile digital telephony (first operated by Radiolinjain in Finland on 19 September, 1988) and the World Wide Web (Tim Berners Lee, 1989). Two other key developments that are enabling the digital information revolution are cheap networked sensors and global positioning systems.

Today, the impact of ICT on economic development and improved quality of life is well established. Studies by the World Bank indicate that in low- and middle-income countries, every 10 percentage point increase in broadband penetration accelerates economic growth by 1,38 percentage points. In South Africa, the Financial Mail, in a feature article on broadband quoted the GSM Association, stated, "Wireless broadband and related industries could generate about 28 000 new jobs and 1.8% GDP by 2015."

CSIR's work in ICT research and development takes its cue from the concept of the information society. Our vision is to contribute to South Africa's development towards and advanced information society in which everyone can benefit from their enhanced ability to create, manipulate, organize, transmit, store, and act on information.

This edition of ScienceScope highlights a number of areas of ICT research in the CSIR. It shows how our work contributes to society, human capital development, and the economy.

Advances in ICT, brought about by research and experimental development, are worthy of pursuit both in terms of enabling impact in areas such as health, energy and the environment, and as an area of impact in itself. Hence we are taking up the 'challenge of untrodden territory' by investing our resources in a portfolio of initiatives aimed at scientific and technological breakthroughs that will broaden and enhance access to ICT and enable novel uses of advanced ICT.



Dr Sibusiso Sibisi,
CSIR President and CEO

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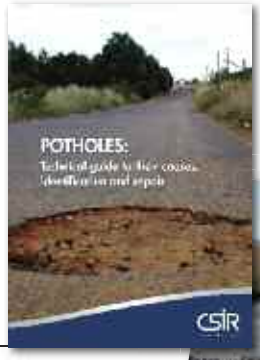
News snippets from around the CSIR



CSIR assists with pothole problem through R&D solution

THE UNPRECEDENTED increase in the number and size of potholes following the past summer rainfall seasons has seen a public outcry and politicians ring-fencing funding to address this situation.

The fixing of potholes is the responsibility of road owners. Since February 2011, CSIR researchers have been training scores of road inspection and maintenance teams nationally to ensure appropriate and effective fixing of potholes. The national Department of Public Works already sent more than 300 people for the training to date, with the South African Road Federation (SARF) and the Asphalt Academy partnering with the CSIR to present training sessions nationally. Metros are starting to take up the opportunity for training, with the City of Tshwane being the first.

The CSIR published appropriate research and development (R&D) solutions for the pothole problem in a technical guideline in December 2010. The guide – used during the training – deals with the causes of potholes, their identification and the various repair methods for different categories of potholes. The CSIR also published a shorter, non-technical document (both are freely available at – www.csir.co.za/pothole_guides).

The guide is the only one of its kind in South Africa and includes an innovative pothole classification system developed by the CSIR. It is used to classify potholes into one of seven categories, with each category requiring a different repair technique to address the fundamental cause of the pothole during the repair process.

– Hilda van Rooyen

Economic growth hampered by logistics costs

SOUTH AFRICA'S consistently high cost of logistics decreased by just 1.2% between 2008 and 2009, from 14.7% to 13.5% of Gross Domestic Product (GDP). Within a recessionary context, this points to an underperforming logistics sector, according to the 7th State of Logistics™ survey released in March 2011.

The survey was initiated by the CSIR in 2004 to provide decision-makers in public and private sectors with proper data, information, etc. about this sector. Secondly, the aim was to quantify important indicators annually to obtain trends over time. Both these have been achieved and it has been acknowledged that the State of Logistics™ survey, released jointly by the CSIR and its partners in this initiative – IMPERIAL Logistics and Stellenbosch University – is an authoritative and important report for the country.

Topics covered in the 7th survey include 'green' logistics (including 'extra distance' measurement); deteriorating road quality and benefit-cost analysis; supply chain risk management; the skills issue; and rural logistics.

For the seven annual surveys released to date, see www.csir.co.za/sol. – Hilda van Rooyen

CSIR helps 'tame' southern ocean with research data

OCEANOGRAPHIC INFORMATION on the southern ocean is crucial to managing southern Africa's long coastline that is exposed to the weather generated over this vast ocean. The highest waves in the world have been observed in the southern ocean, and when the accompanying conditions reach the coast of South Africa, they impact the beaches and affect safe operation of ports and shipping.

The Southern African Data Centre for Oceanography (SADCO) – managed by the CSIR – started providing free and open access to its data during 2010. Data are mostly collected from research vessels, vessels-of-opportunity, moored instruments or floating buoys. Much of this information is entered into global numerical models, such as those used for weather forecasting, to allow some prediction of climate events and trends, and even tracking of oil spills.

SADCO forms part of a global network of ocean data centres. These are all part of the United Nations' Intergovernmental Oceanographic Commission, which was established 50 years ago. SADCO is funded by a consortium comprising the CSIR, the Department of Environmental Affairs, the South African Navy, the South African Environmental Observation Network of the National Research Foundation and the Namibian Ministry of Fisheries and Marine Resources.

SADCO's data include more than 250 000 vertical profile data sets of the southern ocean, with the centre being fully computerised and some data sets dating back as far as 1670!

– Hilda van Rooyen

Waves monitored for safer ports operations

A 'waverider' buoy, which supplies data to the WaveNet monitoring system

MORE THAN THREE-QUARTERS of the world's cargo is transported by sea. Eight of the 13 southern African commercial ports are located in South Africa and owned and managed by the Transnet National Ports Authority (TNPA). The demand for these ports to handle greater amounts of tonnage increases every year.

The CSIR supplies the TNPA with 48-hour wave forecasts for its ports and harbours (seven ports from Saldanha Bay to Richards Bay). The real-time service provided by the CSIR to Transnet includes the monitoring of waves, tides, currents and wind. This is achieved through the WaveNet monitoring system (http:wavenet.csir.co.za). The data lead to improvements in the efficient functioning and safety of South African ports, which handle over 90% of South African international trade.

WaveNet obtains data from – among other components – 'waverider' buoys, which provide environmental data crucial for forecast purposes. An access link was thus also established for the South African Weather Service (SAWS), with data available for the daily operations of SAWS.

– Hilda van Rooyen

Geoportal offers large spatial data sets at the click of a button

IN LINE WITH international and national strategies to provide open and free access to earth observation data, the CSIR is now able to serve researchers and external users with access to over nine terrabytes of geospatial and earth observation data.

Operational since 1 April 2011, the newly-established Geo-Spatial Data Infrastructure (GSDI) allows researchers from all over the world to access large geospatial data sets through the CSIR's Geoportal, with the click of a mouse.

According to CSIR contract research and development manager, Laurie Barwell, the CSIR's Geoportal is in line with international initiatives such as the Global Earth Observation System of Systems (GEOSS) and the South African Earth Observation System of Systems (SAEOSS) that provide open access to spatial data and information: "Through the Geoportal, researchers can discover, view, interrogate and map data relevant to their research or projects. This allows our researchers to share and interact with geospatial data located within a global network of spatial data providers and users via a truly interoperable system based on international standards," he explains.

Enquiries:
Geoportal administrator
gsdi-ICT@csir.co.za
http://gsdi.geoportal.csir.co.za

Researchers in Africa to tap into international research on SET data

"**EASY ACCESS** to reliable, quality research data is paramount in all fields of science, engineering and technology. Increased access to international research data networks and activities allows for the creation of new knowledge, dissemination of existing expertise as well as direct cooperation with peers abroad," says Antony Cooper of the CSIR.

Cooper was elected an Executive Committee member of CODATA, the interdisciplinary and international Committee on Data for Science and Technology. As the only Executive Committee member from Africa, Cooper says: "It is highly relevant for researchers in Africa to increase their utilisation of these international research data networks – ease of access is a major consideration."

CODATA deals with all types of data resulting from experimental measurements, observations and calculations in all fields of science and technology, including physics, biology, geology, astronomy, engineering, environmental science and ecology.

The CSIR's Dr Martie van Deventer and Antony Cooper who both work towards getting researchers in Africa to tap into international research on science and technology data

The expansion of research leads to a corresponding expansion in the amount of data generated. One thus has to ensure the survival of physical as well as electronic data through archives. "For such research data to be utilised fully, mechanisms must be in place to evaluate, preserve, retrieve and disseminate such data. CODATA has a track record of 40 years in this arena; it is an independent scientific committee of the International Council on Science," comments Cooper. CODATA also brings experts who do research on data quality, access, management, etc., together for collaboration and to avoid duplication of efforts.

Research on aspects of scientific and technology data use is undertaken by task and working groups in CODATA. One of these committees namely, the newly-established Data Citation Standards and Practices Task Group, will be developing an acceptable standard way of citing the use of scientific data sets – irrespective of the scientific discipline. The CSIR's Dr Martie van Deventer is representing the African continent on the task group. The task group membership was a deliberate combination of expertise from a number of countries and disciplines to provide an international forum to identify and help reconcile the needs of various stakeholder communities that are already working on the online data citation and attribution issues. "Such groups include researchers, academics, information scientists and publishers," she says.

"Currently, no international citation standard for online data spans all the disciplines of science and technology or could claim general acceptance. Although we are obviously looking at the online data citation practices already in use in continental Europe, the UK and the USA. This is a very opportune time for African stakeholders to ensure that their needs are also represented," she concludes.

– Hilda van Rooyen

Connections extraordinary everywhere: 'Internet of Things'

Imagine a world in which our energy demands are optimised, the load managed and controlled through the intelligent control of appliances, utilities and devices. A world where energy consumption is known, where users are empowered to remotely manage their load demand. Imagine a world where the devices at home could make sense of weather predictions and pre-emptively change settings on 'things' to make our houses more comfortable?

A WORLD WHERE your alarm clock knows to wake you up earlier because of inclement weather which will impact on your transit time to work. Imagine cities with traffic flowing smoothly, where all the empty parking spaces are known and communicated and linked to your destination – regulated by a vast system of 'things' that interact with one another to come up with optimal suggestions for travellers.

Exciting? Definitely, and not that far in the future, according to Dr Louis Coetzee who leads the CSIR's research effort on the 'Internet of Things'.

"This is a world where all our devices and physical entities are connected to the Internet, creating a network of unprecedented scale, each device or physical entity with its own IP number, each with its own published set of 'services', based on the physical attributes and virtual 'personality', allowing us and other devices to interact with the physical world through cyberspace," says Coetzee. These objects are identifiable in terms of status, geo-location and ability – an expanded Internet to which services and intelligence are added. Where the masses of data are intelligently processed, leading to enhanced decision-making and actions. The International Telecommunication Union (ITU) has suggested that the 'Internet of Things' and the world's objects will be connected in both a 'sensory and intelligent manner'. *(International Telecommunications Union, ITU Internet Reports 2005: The Internet of Things. Executive Summary, Geneva: ITU, 2005.)*

A new paradigm

What has made the 'Internet of Things' possible? Thanks to the advent of cheaper processors and memory, shrinking sensors and actuators and improved networking capabilities, Internet connected smart and mobile devices, appliances, vehicles and security systems (to name a few) now number between 50 – 100 billion.

"Many of these things are becoming smaller and smaller, and integrating into everyday life. It is possible to embed intelligence in them and connect them to the Internet," Coetzee notes. "They can sense, compute and act. The information they provide is integrated with information from other connected things, thus allowing for the creation of higher order cloud services available to the connected things." Cloud computing is computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services.

Another factor contributing to the 'Internet of Things' is increasing widespread accessible and affordable broadband Internet connectivity, thus making it easy to integrate 'things' into the Internet. Standards, such as IPv6 (Internet Protocol version 6), and interoperable communication protocols being created and implemented, aid this endeavour.

Tags and markers provide identification of non-smart objects that connect to the Internet. Through this approach, 'non-smart' objects are incorporated into cyberspace. Unique identification by quick response (QR) codes or radio frequency identification (RFID) chips makes it possible to link a physical object to a cyberspace representation containing information about such a thing.

Realising benefits

Coetzee sees the real value of this phenomenon in its potential to support decision-making through computing that "melts invisibly into the fabric of our business, personal and societal environments". Through the integration of things, knowledge benefiting society is created.

The 'Internet of Things' concepts have been demonstrated in a variety of domains: logistics, transport and asset tracking, smart environments, health, energy, defence and agriculture. Harnessing the 'Internet of Things' phenomenon for power management in a suburb is a useful example of its benefits. "By collating patterns of energy usage, it becomes possible to optimise usage, to provide

'INTERNET OF THINGS'

The term, 'Internet of Things', refers to the connectedness of everyday objects ('things') to the Internet. Everything will be connected to everything else – any **place**, any **time**, any **thing**, any **one**, any **service**, creating unprecedented masses of data to store and process.

A QR or quick response code is a specific matrix bar-code (or two-dimensional code), readable by dedicated QR bar-code readers and camera phones. The information encoded can be text, URL (Internet address) or other data

The Internet of Things engineering group: Andrew Smith, Sizakele Mathaba, Laurie Butgereit, Promise Mvelase, Guillaume Olivirin, Dr Louis Coetzee and Dr Nomusa Dlodlo

"The 'Internet of Things' brings closer to home the choices we can make."

targeted information to that suburb," Coetzee notes.

Decision-making at a higher level will also benefit from the 'Internet of Things'. "When we combine environmental data on polluted water and high rainfall, combined with data on deforestation, for example, it's fairly simple to extract information indicating polluted flooding, and act accordingly," Coetzee remarks. He talks of "smart processes and services to support economies, environment and health".

Research challenges

Coetzee admits that while the examples cited above point to the potential of the 'Internet of Things', there are a myriad research questions to be solved. "How do we store the masses of data and interpret information out there? How do we integrate and interact with so many different devices? Is cloud computing the answer?"

He believes a fusion of research trends – distributed intelligence, statistical analysis and mechanisms to ensure interoperability and connectedness to heterogeneous devices and cloud computing – offers the answer. "Our research at the CSIR has demonstrated the success of smaller, vertical solutions, such as finding and identifying misplaced objects or using QR codes for tree identification or communicating important information regarding our environment such as water levels and potential flooding by using 'Internet of Things' concepts," he says.

The concept of smart cities conjures up interaction between people and things (man to machine) and between things (machine to machine). "However, it's a lot more complex, as hard information must be combined with information on variable and varying social activities," Coetzee notes.

"For intelligent integrated smart solutions to become a reality, more research into solutions using distributed intelligence must be done. We need to get to the point where we integrate our previous small vertical solutions."

Unsolved issues in the context of the 'Internet of Things' phenomenon are the rights of individuals: Every user of a smart phone is visible through his connectivity to the Internet! How does this affect people? How does one trust a 'thing'? What if incorrect decisions are made based on information extracted from data? How does one plan to avoid this?

Coetzee is keen to tackle these technical and associated social research challenges with his group of researchers, as the 'Internet of Things' is a worldwide trend. He is adamant that South Africa ought to ramp up its capabilities in this domain to ensure that local solutions can be devised for local problems. "Smart cities utilising 'Internet of Things' concepts are being planned in different countries. Integrated solutions incorporating the physical world, cyberspace and humans are becoming more prevalent."

He concludes, "It is still early in the 'Internet of Things' research cycle, therefore we have ample opportunity to establish international research collaboration and position South Africa in this exciting research domain." – **Biffy van Rooyen**

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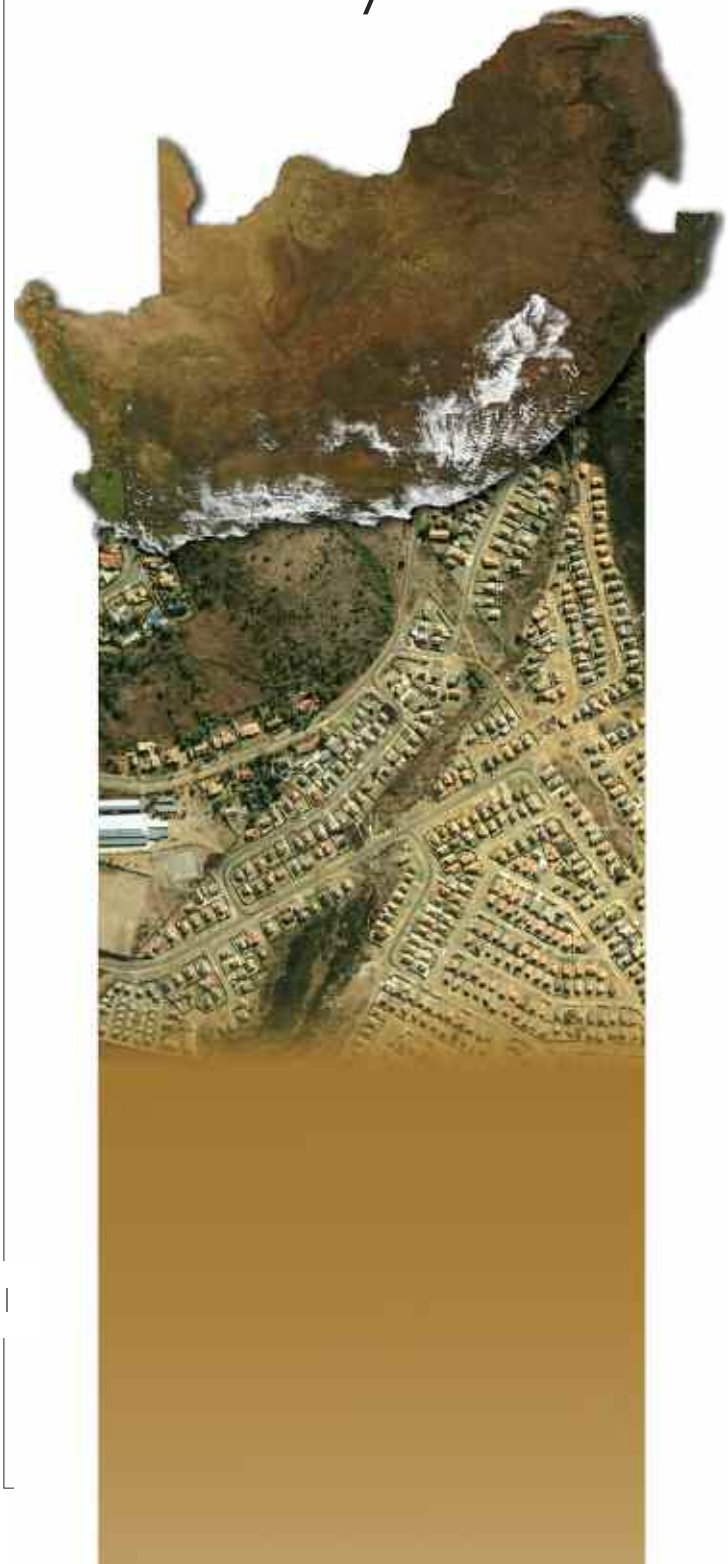
ICT research, development and innovation: Absolutely relevant to earth



Over the past 15 years, the convergence between space technology and information and communications technology (ICT) has seen significant maturity. Initially, this convergence was led by satellite-based communications. Over the past eight years, information processing techniques from the ICT domain have demonstrated an increasing convergence with the processing techniques used on the terabytes of data collected from the constellation of satellites orbiting and monitoring the earth's surface.

Global trends

The important role of space and ICT technology to achieve development objectives was recognised at the Millennium Summit (2000) and the World Summit on Sustainable Development (2002). Of significance to ICT research, development and innovation (RD&I) in earth observation (EO), is the fact that remote sensing and geographic information systems (GIS) were especially highlighted during the 2002 Johannesburg conference as important tools in helping a broad base of stakeholders to manage natural resources and ecosystems. This gave rise to the formation of the intergovernmental Group on Earth Observation (GEO) with South Africa playing a leading role.

Over the last 15 years, earth observation technologies have undergone tremendous advancement. Coarse and medium resolution sensors are making way for hyperspectral, synthetic aperture radar, ultra-high resolution and hyper-temporal EO platforms developed by major space agencies in response to science and environment-related issues. Constellations of micro and medium satellites are emerging as promising tools to assess, monitor and provide data in real-time on natural disasters. Since operational reliability has been established in areas of education, health and environmental sustainability; it is now widely accepted that remote sensing is an important pillar of the information society. Investment in the associated information processing, algorithm development, innovative analytical techniques and management philosophies for large data sets is necessary to keep pace with the advances made in the sensing capabilities.

Weather forecasting, climate research and land use/land change detection and analysis have long depended on satellite systems for

observation

"Unlocking information from the masses of satellite data currently available is a major ICT challenge"

Dr Konrad Wessels

Lee Annamalai

inputs, while benefiting from the ever-improving computing capabilities and modelling and information processing. New research topics borrowing brilliance from communications signal processing (for example, time series analysis), middleware concepts used in transparent networked application development and web service provisioning, applied to remote and *in situ* earth observation sensing, are creating paradigm shifts resulting in the next wave of experimental space technology demonstrators.

While less focus has been on the outputs, there has nonetheless been an improvement in the ability to produce high quality and reliability digital maps; forecast and predict weather behaviour; characterise dynamic earth systems and patterns; and produce frequent, high fidelity measurements of oceans and land change. These advances have resulted in beneficial social impacts resulting in space technology transitioning from experimental tools into critical infrastructure for national development. Acquiring and maintaining skills and knowledge, and gaining and maintaining access to information are accepted as primary enablers to economic opportunity for the poor and marginalised.

The role of GEOSS

Against this backdrop, one of the GEO initiatives is GEOSS, the Global Earth Observation System of Systems, which is simultaneously addressing nine areas of critical importance to people and society. Its many aims are to empower the international community to protect itself against natural and human-induced disasters; understand the environmental sources of health hazards; manage energy resources; respond to climate change and its impacts; safeguard water resources; improve weather forecasts; manage ecosystems; and promote sustainable agriculture and conserve biodiversity.

The South African National Space Strategy places emphasis on moving space technology applications from experimental to everyday use (operationalisation) to derive societal benefits, achieve economic goals and strengthen South Africa's profile in the community of nations. It is therefore critical that ICT RD&I be continued and enhanced among all the actors within the South African space sector, and receives further investment. This will enable South Africa and, indeed, other developing countries to succeed in their efforts towards sustainable social development, mitigating against the devastating effects of natural disasters, and reducing the contributors to climate change.

– Lee Annamalai and Dr Konrad Wessels

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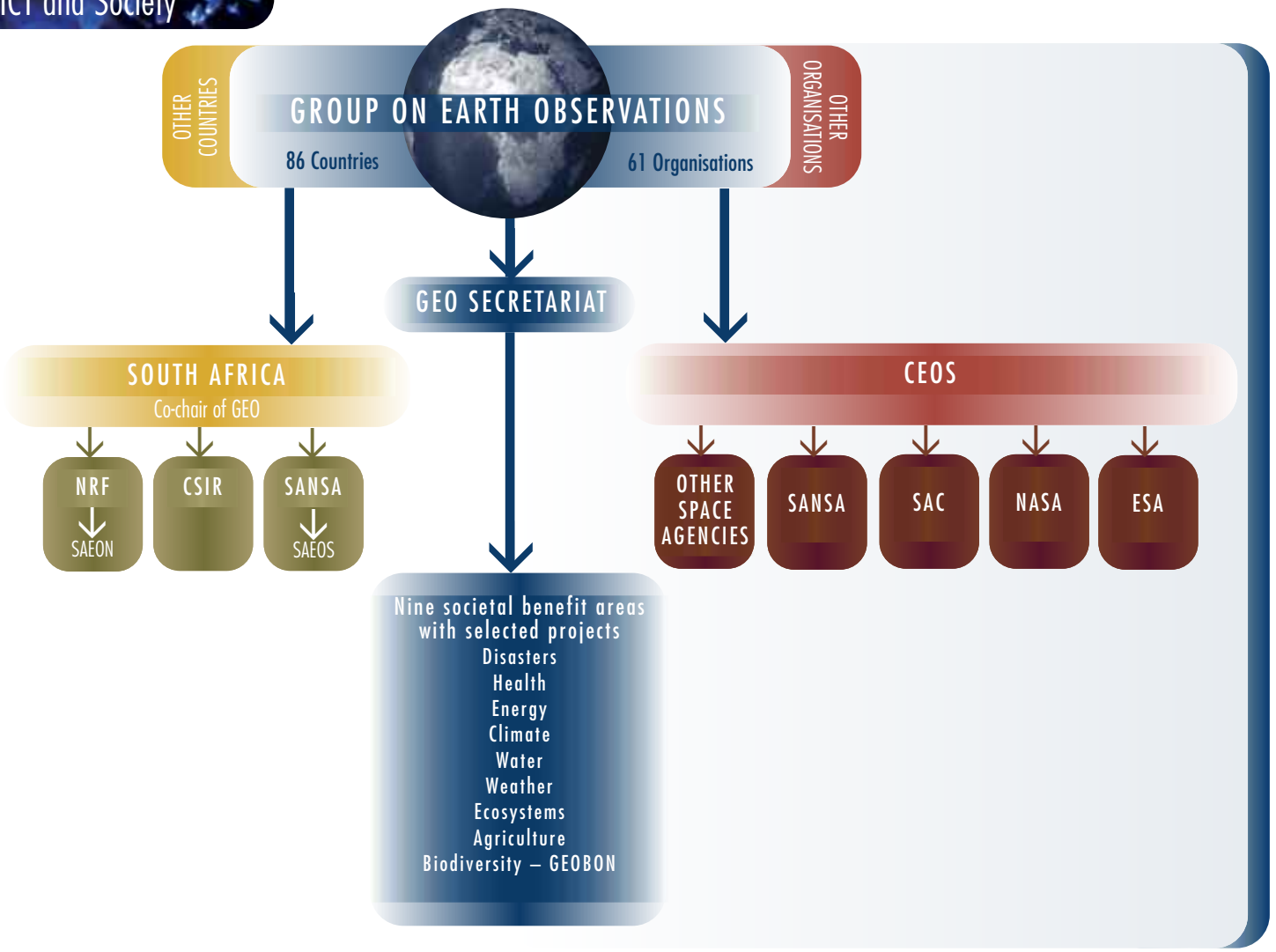


From satellites to pathogens – building a global system of systems to understand planet Earth

WITH A MEMBERSHIP of 86 national governments and 61 participating organisations, the Group on Earth Observations (GEO) has become one of the world's broadest and most inclusive forums for Earth observation and environmental monitoring.

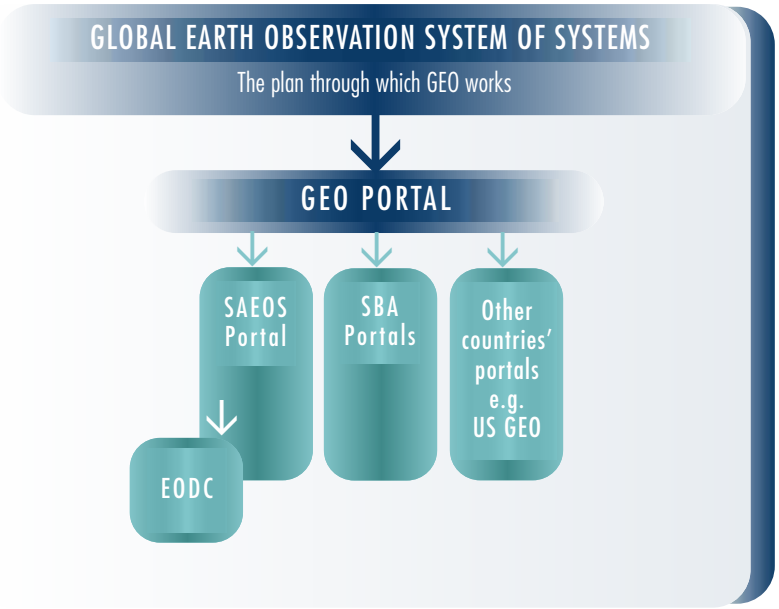
Better usage of Earth environmental data across disciplinary, geographic and political boundaries is essential for addressing environmental crises like tsunamis, droughts, extreme rainfall events and other environmental impacts on humans such as cholera epidemics. To coordinate the collection and analysis of Earth data, GEO has been leading a worldwide effort since 2005 to build a Global Earth Observation System of Systems (GEOSS).

As part of these international efforts, the CSIR is involved in several multi-partner international projects to build systems that link various forms of data sets with each other in a user-friendly and widely-accessible manner for local and international stakeholders.

One of these, the Earth Observation and Environmental monitoring for the mitigation of Health risks (EO2Heaven) project, aims to develop a system whereby different forms of data sets – from the microbial to remote sensing – are coded in such a way as to enable environmental researchers to combine it with Earth observation data in larger-scale models by the click of a button (see pages 12-13).

In another project, botanist and remote sensing specialist Dr Melanie Lück-Vogel is testing the transferability of the methods developed by EBONE in the European context for the large scale application in non-European Mediterranean regions like the Sandveld in the Western Cape. EBONE is the European contribution to the GEO Biodiversity Observation Network (GEO BON), a network dedicated to the development of standardised global biodiversity monitoring systems.

Lastly, Dr Stewart Bernard is working towards the establishment of a South African multi-institutional marine remote sensing unit, developing methods according to GEO principles to monitor water quality and specifically eutrophication in coastal and inland waters (see page 17).



Dr Terence van Zyl leads the Sensor Web Enablement for In-Situ Observing Network Facilitation task. The task fosters the development of space-borne, air-borne, sea-based and ground-based sensing networks (sensor webs) and considers scenarios or use cases that demonstrate the value of sensor webs to the societal benefit areas for example, disasters, health, biodiversity, ecosystems and water.

Karel Matthee is editor of the GEONET Mobile task which supports broader dissemination and distribution networks. It focuses on delivery of information, derived from earth observations data, to people living in rural areas with only access to mobile phone technology.

Dr Stewart Bernard is closely involved with three GEO tasks focused on developing operational observation systems, as part of the GEO system of systems. The Global Water Quality Information System seeks to develop a fully operational, spatially-comprehensive water quality information system in inland and coastal waters. Contributing national research initiatives are the CSIR-funded Safe Water Earth Observation System (SWEOS) project, developing this capability for local pilot ecosystems; and aligned DST-funded initiatives to build operational capability.

The Chlorophyll Globally Integrated Network (ChloroGIN) aims to broadly disseminate accessible marine EO products, and empower users through training. Bernard is closely involved with implementing these aims for Africa through EU-funded projects such as: the Europe Africa Marine-Network (EAMNet) and GEONETCast for and by Developing Countries (DevCoCast).

Finally, the GEO Building Capacity for Operational Oceanography task seeks to develop systems for real-time ocean observation and forecasting, which is implemented nationally through the multi-institutional OceanSAfrica initiative.

WHY A GLOBAL SYSTEM?

ALL OVER THE WORLD, many satellites with sensors to measure changes in the atmosphere, water and on land have been launched; tens of thousands of surface stations have been deployed in the water, on the land, and in the atmosphere using sensors aboard aircraft to measure and analyse the atmosphere and the land, and water surface below them on a regular basis. This massive amount of data has the potential to help us in many ways, from weather prediction to disaster management.

But many of these systems are built independently by governments and organisations for their own purposes, and, in the past, the recurrent problem of a lack of interoperability has made them inaccessible to researchers and decision-makers.

Supported by groups of international teams working to develop technology based on international standards, GEOSS builds upon existing national, regional, and international systems to provide comprehensive, coordinated Earth observations from thousands of instruments worldwide. The resulting system of cooperation provides an international mechanism to broaden the utility of these data into vital information for society in general, as well as domain specific.

In order to become a member of GEO, a government or organisation has to accept the basic principles of the sharing of data, information and observation systems. The South African government's participation has been through the Department of Science and Technology and it has played a leading role since the establishment of GEO.

Source: Earthzine available at http://www.earthzine.org

LEGEND

DST	Department of Science and Technology
NRF	National Research Foundation
SAEOS	South African Earth Observation Strategy
SANSA	South African National Space Agency
CEOS	Committee on Earth Observation Satellites
NASA	National Aeronautics and Space Agency
ESA	European Space Agency
GEO BON	GEO Biodiversity Observation Network
EBONE	European Biodiversity Observation Network
EO2Heaven	Earth Observation and Environmental modelling for the mitigation of Health risks
EODC	Earth Observation Data Centre
SBA	Societal Benefit Areas
USGEO	United States Group on Earth Observation

Microbiologists, data analysts, modellers and computer scientists are joining forces to harness the advantages offered by new technologies and Earth observation data to build dynamic models of ecosystems and their environmental characteristics.

THE RAISON D'ÊTRE of these models will be to assist environmental managers and decision-makers to identify and then mitigate the impact of environmental health risks such as cholera.

"It is very difficult to understand an ecosystem from only one perspective. For example, as a microbiologist, I can identify a cholera bacterium in a water sample. But that does not mean there is going to be a cholera outbreak tomorrow," explains senior researcher, Dr Martella du Preez.

In order to be able to provide an early warning system, for example, researchers need to characterise an entire catchment, and only once they have modelled it, can they start to explore what would happen when environmental conditions start changing in such a way as to be conducive to a cholera outbreak. A cholera epidemic, for example, is driven by a variety of environmental factors such as rain, temperature and UV light, as well as human-related factors such as a settlement's proximity to water sources, Du Preez explains.

Combining and analysing different data sets

Funded by the European Union, the Earth Observation and Environmental modelling for the mitigation of Health risks (EO2Heaven) project aims to take one step further and develop a system whereby data sets from environmental researchers can be combined with other data sets such as remote sensing images and other Earth observation data.

According to Du Preez, her team generates massive amounts of data: "In the Loskop Dam and Groblersdal area, for example, we have over two years of data on water quality, air and water temperature, land-use practices and more, but the data remain localised to the specific sampling sites and no-one else has access to it.

"If we link this data set with Earth observation data we can start to understand what is happening on a catchment level scale. In the same way, Earth observation and remote sensing data are often not useable until someone has geo-

From satellites to pathogens – mapping the environmental drivers of cholera epidemics on a larger scale

located them precisely with physical reference points on the ground in a process we call 'ground-truthing'. In some instances, we literally take the samples on the ground, at the same moment the satellite passes over the sampling area," she explains.

However, transforming the microbiological data into a product that can talk to other data sets is no easy task. Data sets from various sources need to be coded and then translated using algorithms so that you can compare them with another data set, often using advanced statistical techniques, explains modelling expert Marna van der Merwe.

With a background in microbiology, Van der Merwe acts as the link between the microbiologists and the computer specialists who are building the information architecture so that microbiologists like Du Preez only need to press a button to get access to these data sets and experiment with the variables.

"As soon as you have a data set covering an entire catchment, region, or a country like Uganda, then we can go really small and produce maps of those areas most impacted by cholera, without losing sight of what is happening on catchment or regional scale," says Van der Merwe.

"A satellite cannot identify or sense what kind of pathogens there are in the water – for that we need the microbiology data from the field. However, when linking the microbiology and water quality data sets with earth observation data, we can see how environmental factors like temperature, rain and ultra violet radiation play a role in the onset of a cholera epidemic," she explains.

WHAT ARE OPEN GEOSPATIAL CONSORTIUM (OGC) STANDARDS?

The EO2Heaven system is based on internationally-accepted Open Geospatial Consortium (OGC) standards. OGC is the 'standards' body for the Earth observation community and their standards have been adopted by the Group on Earth Observations (GEO) to standardise data sets internationally – a concept termed 'data democracy'. In other words, if data sets and systems conform to OGC standards, you will be able to link it to the Global Earth Observation System of Systems (GEOSS).

The South African response in support of GEOSS is embodied in the South African Environmental Observation Strategy (SAEOS). The South African Environmental Observation Network (SAEON) portal will provide an entry point to the SAEOS platform.

Challenge to computer scientists

For Grame McFerren and Dr Anwar Vahed, computer scientists, the most important aspect is the breaking down of silos. "We have isolated, fragmented and incoherent systems that limit the use of very expensive data sets, collected by public institutions like the CSIR.

"The most difficult part of this project is not necessarily the science or development of the technology, but changing people's attitudes. Often researchers confuse custodianship of data sets with ownership. Data sets are not intellectual property – it should be made available to the wider community.

"It is also extremely expensive to generate these data sets. It is therefore important that we coordinate efforts to prevent duplication."

The cholera case study is a first attempt to present environmental-health data in an OGC compliant way to benefit society.

Computer scientist and systems architect, Dr Terence van Zyl concurs: "The challenge is not technical, but people. Fortunately we have a wonderful team of researchers on this project, eager to try new things and opening up to the possibilities a system like this can offer. "In this regard, we are teaching the Europeans a few things!" he laughs.

Van Zyl explains that even though environmental researchers and microbiologists will not need to know too much about information and communications technology (ICT) to operate the system, they still retain control over their data sets and how it is used in models and maps by means of the scientific workflow concept (see page 15).

"Previously, environmental researchers would carefully sample an area for two to three years before they then compile the data to produce a static map that is true for those three years. For any future work they would have to go through the whole process again. "With our system, once a catchment or ecosystem has been modelled, you only need to feed it with the latest field data to see how it is changing. You can also go back and change the parameters and see how that's influencing the system. Once you've modelled a catchment, it is so much easier for us as humans to understand what is happening to that system," Van Zyl explains.

–Wiida Basson

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Enhancing African environmental management through ICT

The CSIR's expertise in developing fire products has seen it take on an important role in the South African Development Community (SADC) economic region as part of the African Monitoring of the Environment for Sustainable Development (AMESD) project. AMESD is the outcome of an investment by the European Development Fund (EDF) and a partnership between the African Union (AU) Commission, the European Union (EU) Commission, the five African Regional Economic Communities and the Secretariat of the African, Caribbean and Pacific Group of States (ACP).

Promoting informed decision-making for environmental monitoring in Africa

What is AMESD?

It is a continental-wide, pan-African project for the development of geo-information services. Its aim is to improve decision-making processes in the fields of environmental resource and environmental risk management in Africa. This is done by increasing the information management capacity of African regional and national institutions mandated for environment-related sectors, and by facilitating access to Africa-wide environmental information derived from earth observation technologies.

Leading the CSIR's participation in AMESD is Philip Frost, a CSIR Earth observation specialist who was responsible for developing the Advanced Fire Information System (AFIS) together with Eskom. His task now is to use an innovative combination of information and communications technologies (ICTs) to ensure that fire services and products developed at the CSIR are replicated in the SADC. Frost explains, "The fire service is part of the thematic action (THEMA) for the SADC region, with the focus on agricultural and environmental resource management."

An agricultural service and drought service are also planned in addition to the fire service." These two services are being addressed by the Agricultural Research Council in South Africa.

The nature of the services to be provided in line with the SADC THEMA was determined through a series of consultative SADC workshops with stakeholders. Needs expressed by national ministries of agriculture and of the environment have had to be matched by services.

Novel ICT combinations

The novelty of the AMESD project relies in part on the manner by which information is disseminated. Frost points out, "Dissemination is completely Internet independent via a communications satellite. The GEONetCast dissemination portal requires the CSIR to provide daily products via a file transfer protocol server to Germany. These products are then pushed up to the communications satellite and downloaded to receiving stations.

Frost is overseeing the roll out of 20 receiving stations, one for each ministry of the environment in the SADC region, "The AFIS terminal will be used as part of the receiving stations." Through remote access, software will be continuously downloaded to ensure that receiving stations remain in prime working condition. Fixed mesh antennas of 2.1 m are the second vital component of these receiving stations to be installed."

Novel ICT products

Frost ensures that the SADC receiving stations have access to the CSIR's live fire alerts and fire danger alerts. "These products are developed from the data received by the CSIR Satellite Applications Centre and are constantly being validated," he confirms. Active fire alerts are displayed as the main screen; these are derived from the moderate resolution imaging spectroradiometer (MODIS) and MSG. The fire danger product is derived from the fire weather index (temperature, humidity, rainfall and wind) by using the conformal-cubic atmospheric (CCAM) model. The CCAM is a variable-resolution model, developed by CSIRO modellers in Australia, and is run oper-

Decision-making for environmental management: EDF investment in Africa

2002 – 2005
Project for the Utilisation of Meteosat Second Generation (MSG) Satellite in Africa (PUMA) €11 m

2010 – 2013
AMESD €21 m

2013 – 2016
Monitoring of the Environment for Security (MESA)

Scientific workflows in support of Earth observation science

The EO4Vistrails team: (from left, clockwise): Dr Terence van Zyl, Bheki Cwele. Bolelang Sibolla, Dr Anwar Vahed, Derek Hohls, Graeme McFerren and Petrus Shabangu

"It's like a high-tech lab notebook"

THE 'TRIED AND TRUSTED' method of documenting scientific data and methods in laboratory manuals is slowly but surely changing as scientific workflows for various domains gain traction. This according to Dr Terence van Zyl, who is part of the team that leads the CSIR's research on scientific workflows for earth observation (EO).

What are scientific workflows?

A scientific workflow system is a specialised form of a workflow management system designed specifically to compose and execute a series of computational or data manipulation steps, or a workflow, in a scientific application. What makes scientific workflows so valuable is the fact that a process followed during scientific work can be reused and repeated, and has provenance. "The same piece of software can be used for a different application," Van Zyl points out. "In scientific workflows, provenance refer to capturing of the steps and alternative paths followed, as well as the results obtained during data exploration. "Having this information at one's disposal provides a history of the success and/or failure that constituted the scientific endeavour," he notes. "This means that one can revisit the work and take alternative paths from the work to explore different aspects."

Scientific workflows for earth observation

Van Zyl's team is keen to prove that scientific workflows can be used operationally for EO science. "Scientific workflows can bridge the gap between EO and statistical toolsets, such as R, which have specific applications," he explains.

"We are also working to narrow the gap between geospatial toolsets, such as GRASS and PySAL, and scientific workflows." R, GRASS (Geographic Resources Analysis Support System) and PySAL (a library of spatial analytic functions based on the Python programming language) are all open source toolsets used in the EO domain.

The CSIR's research focuses on information and communications technology (ICT) for EO and operates within the workspace of the OGC (Open Geospatial Consortium) and its Sensor Web Enablement (SWE) framework. The OGC is an international voluntary standards organisation encouraging development and implementation of open standards for geospatial content and services. SWE standards enable developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and usable via the web. "We are planning to bring tools from this workspace into scientific workflows," Van Zyl confirms.

Van Zyl and his team have developed a package in VisTrails, a scientific workflow management system developed at the Scientific Computing and Imaging Institute at the University of Utah in the United States. VisTrails provides support for data exploration and visualisation. EO4VisTrails is a pilot for their research in preparation for making it operational. The team aims to have a spatial analytical demonstrator up and running soon.

In conclusion, Van Zyl emphasises the value of scientific workflows in supporting innovation. "When we develop a scientific workflow to determine, for example, how close houses are to the coast, it becomes possible to reuse this science effectively for many applications, such as decision-making regarding risks and vulnerability." Risks and vulnerability are relevant to business, environmental management and government, to name a few.

The scientific workflows team regards the larger scientific community who would derive value from this research as their 'clients'. Van Zyl is looking forward to future collaboration on scientific projects locally and internationally. – Biffy van Rooyen

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For more information, visit
http://code.google.com/p/eo4vistrails/

tionally on the computers of the CSIR Climate Studies, Modelling and Environmental Health group. The operational weather forecasts are produced early-morning every day at a horizontal resolution of 15 km for the next 7 days. The third product, the burnt area estimate, is supplied monthly to assist in calculating areas affected by fire; this can in turn be used to calculate carbon dioxide emissions.

Helping to realise AMESD through training

The CSIR has taken on the joint responsibility for training representatives of SADC ministries in the use of the fire service, along with the universities of Botswana and Zimbabwe who provide the training for agriculture and drought services respectively. This involves immersing trainees in theory and case studies, as well as the writing of manuals.

– Biffy van Rooyen

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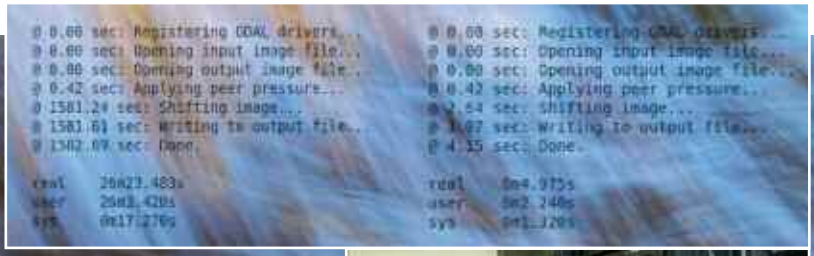

The running time comparison between in-house developed algorithms running on the CPU (left) and GPU (right) hardware as shown here demonstrates the remarkable increase in processing speed.

High performance computing revolutionises earth observation image processing

A recently-acquired high performance computing solution has revolutionised the processing speed of remote-sensing products from satellite over-pass data with as much as 700 times.

Riaan van den Dool next to the NVIDIA system and its host server (an HP DL380)

The Earth Observation (EO) unit at the CSIR Satellite Applications Centre centralised the CSIR's EO services into a spatial portal that acquires, archives, processes and distributes remotely-sensed data from EO satellites. The data are processed as remote-sensing products and imagery and provide valuable input for a broad range of decision-makers.

THE SOLUTION IS BASED on graphical processing unit (GPU) hardware obtained from multinational specialist supplier NVIDIA at a fraction of the cost of central processing unit (CPU) high performance computing.

Used in more than 90% of new desktop and notebook computers, a GPU is a specialised microprocessor that offloads and accelerates image computation from the CPU. Modern GPUs are very efficient at manipulating images and their highly parallel structure makes them more effective than general-purpose CPUs for a range of complex algorithms.

"The architecture of the compact NVIDIA Tesla s2050 system is called SIMD (Single Instruction Multiple Data) and contains 1 796 processing cores for parallel data processing and is highly suited to processing complete images using the same algorithm," according to Riaan van den Dool, Group Leader: Advanced Image Processing at the CSIR.

"We are experiencing a significant increase in processing speed between in-house developed algorithms running on CPU and those using GPU hardware. The remarkable difference in the time taken by the two processes is illustrated in the figure above, which reflects a speed-up of roughly 700 times. This performance bodes well for processing large amounts of data using complicated image processing algorithms, which will enable the CSIR to timeously deliver products dependent on order-driven processing," says Van den Dool.

The newly-acquired GPU hardware complements the data and information management system or DIMS, which integrates the CSIR's SARMES[1] processing suite and several other processors. This creates an advanced customer search and order interface.

"The growing number of received satellites, diversity of data and demand for products continuously drive the need to stay at the cutting-edge of highly automated data and processing management. Our multi-mission EO data management system approach gives us the flexibility to do this. We are excited about the new GPU capability and the improved speed with which we can process imagery for our customers," says Wolfgang Lück, a technical manager at the CSIR.

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GPUs at their best

The utilisation of GPUs in HPC is gaining momentum. Three systems in the TOP10 of the TOP500 list of the world's fastest supercomputers are based on GPU architecture, which confirms how fast GPU systems can be. The Number 1 system on the TOP500, Tianhe-1 (self-built by the National Defense University of Technology in China), is based on the GPU architecture.

The Centre for High Performance Computing (CHPC in Cape Town) has a GPU cluster of 20 NVIDIA cards as a test-bed for users to test their applications. NVIDIA is an American global technology company which specialises in the development of graphics processing units. Good acceleration of the in-house CFD (computational fluid dynamics) CODE developed by the CSIR's Dr Arnaud Malan has been achieved. An increase in applications benefitting from accelerators such as GPU may result in a national system built around this architecture.

[1] South African Resource Management and Expert System developed in-house at the CSIR by a technical manager, Wolfgang Lück.

New systems developed to study water quality and eutrophication

Eutrophic states can occur in both inland and ocean water bodies when elevated nutrient levels occur. It can lead to algal growth which may be toxic or greatly reduce the dissolved oxygen levels in water. The result is the death of plants and creatures that are natural and vital to the ecosystem.

WHEN CSIR RESEARCHERS needed new types of equipment with which to gather scientific data from water bodies to study the occurrence of harmful algae and eutrophic states, they called in assistance from their research engineering colleagues in the fields of mechatronics and sensor science.

Currently, there is little understanding of the mechanisms by which eutrophic states occur, and under-developed national infrastructure to measure eutrophication in real-time. To better observe and fully understand eutrophication scientifically, data are needed, preferably in the form of real or near real-time systems coupled with new data products from Earth observation satellites. But the equipment and methods with which to gather data are prohibitively expensive and not always suited to South African conditions.

CSIR oceanographer, Dr Stewart Bernard, explains: "The Benguela current off the south-west coast of South Africa is regarded as one of the most productive ecosystems in the world. The inland waters we work in also can contain very high concentrations of algae, particularly noxious cyanobacteria. Our local conditions and systems are therefore very demanding for satellite and buoy-based measurements, and require the development of new techniques, platforms and sensors."

For South Africa to have this kind of technology at hand and at low cost, will have a huge impact on our ability to monitor water quality issues such as red tide on the west coast or problems with cyanobacteria and eutrophication in inland waters: "Currently, marine research vessels cost about R100 000 a day to operate, and are unable to provide daily observations, while commercially-available autonomous measurement systems can be prohibitively expensive or unsuitable for local conditions. Earth observation data, coupled with measurements from critically-located buoys, can offer very low-cost data in near real-time across many different ecosystems," Bernard says.

The CSIR's Safe Water Earth Observation Systems (SWEOS) project's aim is to build Earth observation-based information systems to provide products for ecosystem monitoring and characterisation, ultimately facilitating a predictive capability. The new buoys will be used both to provide real-time data on algal blooms, and to develop and verify new satellite techniques, which will then allow satellite data records from 10 years or longer to be used to characterise change in South African coastal and inland ecosystems.

The buoy solution, according to the CSIR's Johan Olivier, who project-managed and undertook the mechanical design work on the system "is a pencil buoy specifically developed for water observations. It needed to have a low-cost, low-weight design which is easy and fast to deploy". In addition to the buoy, the CSIR's Optronics group is developing new low-cost radiometric sensors, with the aim of greatly reducing system costs.

The CSIR's Peter Bosscha, responsible for the electronic and software development work, explains: "The buoy's electronics have a very low power design which can stay deployed for a long time without requiring maintenance. Solar panels are used to keep the buoy's battery topped up and data are collected at regular intervals. Data can be stored on board but can also be relayed via a GSM (cell phone) network to a central server."

The CSIR-developed buoy dubbed 'Gizmo' was tested at Elands Bay on the south-west coast from 23 February to 14 March 2011 by a team of scientists from the CSIR, the Department of Agriculture, Forestry and Fisheries and the University of Cape Town.

The CSIR-developed SWEOS buoy bobs in a test pool at the CSIR before being shipped to the coast for tests in the ocean. Only half of the buoy is visible above the water.

The buoy can be used for both ocean and inland water monitoring, and initial trials were held at Hartbeespoort Dam in September 2010 with a prototype assembly. After further mechanical, electronic and software work, the buoy is currently undergoing sea trials in the Southern Benguela, one of the world's most productive upwelling systems. During these trials, algal blooms are monitored which can have a detrimental effect on fisheries. The next stop will be Loskop Dam in Mpumalanga.

The buoy, affectionately dubbed 'Gizmo', is equipped with sensors for radiometry, fluorescence/back scatter, temperature, wind speed, water current speed and GPS.

The development of the new buoy and sensor also serves as 'proof of concept' that the CSIR has the capability to design and build low-cost robotic observation systems for aquatic ecosystems. The ultimate aim is to develop new technology that allows hundreds or even thousands of robotic sensors to provide much-needed environmental data for inland, coastal and deep ocean ecosystems.

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Research aids sustainable planning of cities 30 years ahead

Through urban simulation expertise, CSIR researchers assist metros with enhanced planning in and around cities, including service delivery and infrastructure development, for up to 30 years into the future.

"AS THE ENGINES of national growth, South Africa's cities need to create jobs and provide adequate shelter, infrastructure and services to alleviate poverty and improve the health and safety profile of their inhabitants while stimulating vibrant economies and promoting more sustainable, energy-efficient urban settlements," says Dr Louis Waldeck who heads the CSIR's Urban Dynamics Laboratory.

The populations of these cities are growing rapidly and like in many other countries, many South Africans are moving from rural areas to cities in search of a better life. During 2005, 59.3% of the South African population lived in urban areas compared to the global average of 48.7%. It is expected that 71.3% of the South African population will be urbanised by 2030.

South Africa's four largest metropolitan areas and their immediate surrounding regions are home to more than 38% of the national population. The growing and diverse economies of these metropolitan areas generate more than 66% of the national economy and form the backbone of South Africa's economy.

"The CSIR laboratory provides the experimental space within which likely patterns of urban growth can be studied 30 years into the future, thus allowing planners and decision-makers to evaluate the long-term impact of spatial policies and investment decisions that our large cities are making today," comments Waldeck. The laboratory brings together a trans-disciplinary team and a numerical modelling and simulation platform that look at cities, regions and their development trajectories as complex, adaptive social-ecological systems.

The current simulation platform is based on various open-source software projects. UrbanSim is used for micro-simulation of the choices made by individual households and businesses as consumers of property and services, developers as suppliers of property, as well as government as a supplier of infrastructure and services. MATSim simulates the behaviour of transportation systems from individuals pursuing their daily activity schedules. "Current individual choice capabilities include route choice, activity timing, activity and activity location choice, mode choice and transfer between modes (e.g. park and ride), toll avoidance and information feedback response (e.g. radio traffic reports)," notes Waldeck.
A major obstacle to applying micro-simulation and agent-based techniques in the developing world is the availability of data as these techniques require information about individual households, jobs, buildings, vehicles, etc. Some of this information can be derived from the 10% sample of Census 2001 forms made available to the CSIR team by Statistics South Africa (Stats SA).

"This allows us to generate a 'synthetic' population that is statistically representative of the real population in a city. We have an excellent working relationship with Stats SA, who has gone out of its way to make special extracts available to improve the quality of our 'synthetic' populations. For researchers in our field, Census 2011 is very exciting, as we will have a new baseline for our simulations. Other micro-level information can be deduced from the zoning and valuation-roll information kept by municipalities," explains Waldeck.
As part of its drive to harness spatial information and communications technology (ICT) in support of development agencies to bring about improved quality of life, the Department of Science and Technology (DST) commissioned the integrated development planning and modelling project (IPDM). The development of the IPDM, aimed at supporting integrated planning, development and service delivery for South Africa, is undertaken by the CSIR and the Human Sciences Research Council, in collaboration with various universities.

The IPDM not only involves the first major application of the CSIR's simulation capability in the cities of eThekwini, Johannesburg, Nelson Mandela Bay and the entire Gauteng Global City Region, but an adaptation of technologies originating from a developed

Simulated residential urban expansion at land parcel scale between 2001 and 2007

world context to uniquely South African circumstances. Further details about the IPDM project are available at http://stepsa.org.
The CSIR's Maria Coetzee, project leader of the IPDM, explains that the results of the simulation process will enable metros and city regions to plan more proactively for the long term by better understanding:

- Future patterns of demand for infrastructure, facilities and services such as water, electricity, sanitation, schools, clinics and hospitals.
- The investments that will be required to sustain the economy, including public and private transport.
- How future urban forms may impact the sustainability of our cities by using indicators such as travel time and costs, access to social and economic opportunities, and energy and carbon efficiency.

The IPDM team uses a living laboratory approach, involving the planners and city decision-makers of South Africa's major metropolitan areas in a series of interactive work sessions to develop, test and apply the ICT platform in real-life contexts of respective cities or city regions.

"Some of the main activities of the living laboratories include the development of various demographic, employment and spatial planning policy scenarios to be simulated by the UrbanSim/MATSim platform. This will enable planners in these metros to assess the possible future impacts of their current growth management strategies and spatial frameworks," concludes Coetzee.

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With the Tshwane city landscape in the background, Dr Louis Waldeck, manager of planning support systems at the CSIR and research group leader Maria Coetzee

HLT operations manager, Dr Karen Calteaux

CSIR and North-West University language technologists together with Google, **pioneer the spoken web** in South African English, isiZulu and Afrikaans

UNTIL RECENTLY, BROWSING, navigating, filtering and processing of information on the interweb could only be done through text-based language. However, Google has pioneered a technology that allows people to access the web using the spoken word. Through its new technology, Google has launched a service dubbed 'Voice Search' that enables Internet users to do Google searches by speaking into their cell phones, making it possible to search on Google using voice in the same way as one would search by typing in a search query. Users download an application on their smart phone and call the Internet to obtain information. On average, one voice search is about 100Kb and uses an acoustic, pronunciation and language model to produce accurate results based on search queries.

Enter the CSIR and North-West University

Voice Search is available in South Africa in South African English, isiZulu and Afrikaans because of the work done by the CSIR's and North-West University's human language technologists.

Human language technologists range from engineers, computer scientists, statisticians, mathematicians to linguists, sociolinguists and sociologists. They apply their expertise in the multidisciplinary field known as Human Language Technology (HLT).
The CSIR has its own team of researchers who specialise in human language technologies. "The HLT group's focus is really about applying science to enable people to interact with machines using natural language," says Dr Karen Calteaux, operations manager at the CSIR's HLT group. "We are particularly motivated by research that is relevant and applicable to South African languages and ICT for development," she adds.

HLT research

Calteaux indicates that the team of HLT researchers investigate how HLT can be adapted and applied to benefit users in developing countries. According to Calteaux, HLT research rests on three major pillars namely: developing speech technologies within a multilingual environment and for resource-scarce languages; seeking real-world situations where these speech technologies can be tested, applied and promoted; and growing future human language technologists. The group continually produces top-achieving students, says Calteaux. "Five of the Master's degrees emanating from the group between 2009 and 2010, were awarded cum laude," she adds.

She defines HLT as an enabling technology that can play a crucial role in addressing social cohesiveness and development by empowering people with access to information. "Telephone-based systems using HLTs such as automatic speech recognition and text-to-speech synthesis now allow people to access information in more than one language using voice, which is ubiquitous," she adds.

HLT in action in SA

In South Africa, HLT is used in efforts to support language diversity in an affordable and equitable manner, explains Calteaux. HLT is also used to assist industry and government to make services and documents available in all 11 official languages. Thus HLT has a major role to play in rectifying the historical discrimination against specific languages.

In this regard, the HLT team has been involved in Project Lwazi, an initiative co-funded by the departments of Arts and Culture (DAC), and Science and Technology (DST). The aim of Project Lwazi is to increase the impact of speech technologies in South Africa by showing how these can enhance and facilitate socioeconomic development through telephone-based, speech-driven information systems. – **Bandile Sikwane**

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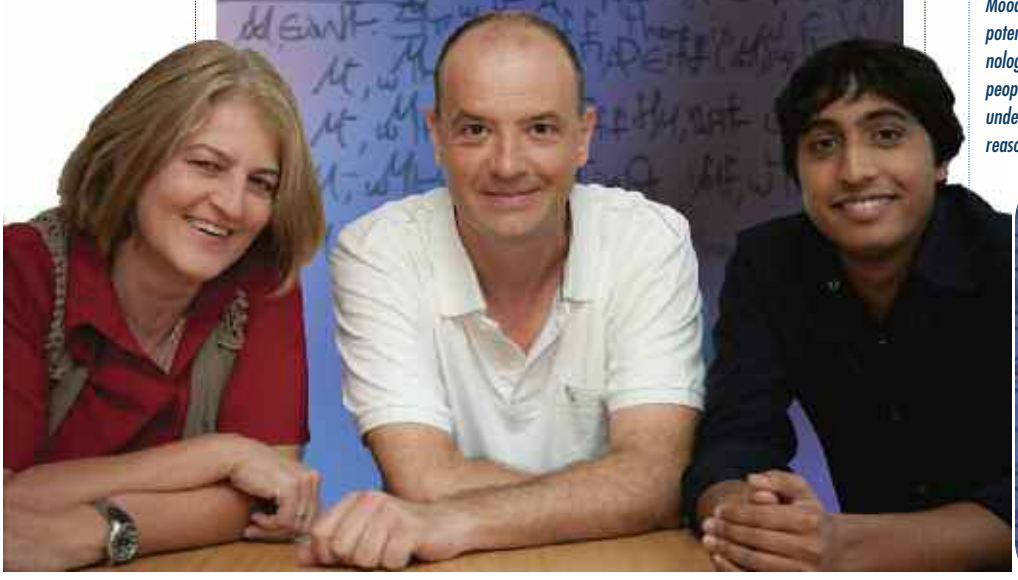
Uncovering new knowledge in scientific domains using ontologies

In February 2011, Watson, the IBM supercomputer, took the crown as Jeopardy winner. Watson had beaten two of the most successful players ever to have taken part in this American quiz show featuring trivia in history, literature, the arts, pop culture, science, sports, geography, wordplay and more.



The CSIR's Aurona Gerber, Tommie Meyer and Kodylan Moodley are excited by the potential that ontology technologies promise, enabling people and machines to understand, share and reason using knowledge

Logical inferencing:

New facts can be inferred from asserted facts through logical consequence, for example:

- In summer, all days are hot.
- On a hot day, it always rains.
- Therefore, it rains on all summer days.

WHAT MADE IT POSSIBLE for Watson to compete against and beat its human competitors by providing quick responses to rapid questions with hidden meanings, puns and riddles? Part of the explanation lies in the use of ontologies. This field of research at the CSIR is led by Dr Tommie Meyer.

Ontologies and knowledge representation enable the development of semantic technologies (semantic pertains to meaning in language), by which meaning is encoded to make it possible for people and machines to understand, share and reason using knowledge. This differs greatly from hard-coded information used in traditional information technology. For the latter, queries can retrieve only facts that have been captured and stored, but do not make connections or inferences (deriving logical conclusions) to come up with new information.

Using the logical inference that is part of formal ontologies, it becomes possible to come up with new information from the facts that have been captured. Herein lies the differentiator of ontologies: It offers a way to derive value from existing information in a particular domain.

Ontologies have already proved to be of value in the domain of genetics as a component of a unique research method being used to solve complex problems.

So, which domain is up next for the ontological treatment? Two new domains to benefit from ontology research are biodiversity and ecosystems, both of which are cited as part of the 2010 National Government Performance Measurement Outcomes: 'Environmental assets and natural resources that are well protected and continually enhanced'.

How to create an ontology for a domain

Dr Aurona Gerber, who is passionate about ontologies, explains the process of creating an ontology. "First we need a shared, consensual and conceptual domain model, as it's all about talking the same language as the domain experts," she says. Agreed terminology and shared vocabulary are essential.

Domain experts in natural sciences define and share expert terminology. The role of the onto-

logy researcher is to capture this real knowledge in a format that is accessible to a computer through the use of logic-founded knowledge representation.

Once this process has been completed, the knowledge representation is checked for consistency. "Now comes the really exciting part," Gerber notes. "Our conceptual model has thousands of concepts and ten times as many relations. When we add data to the concepts, new classifications become possible, thereby adding new knowledge to the domain." The equivalent outcome through fieldwork, experimentation and other methods such as research algorithms, often takes years to achieve.

Gerber is excited when confronted with the issue of masses of data stored in different databases, "It's theoretically possible to couple these repositories with domain models to integrate information at the semantic level." Advanced querying mechanisms can then be investigated to exploit complex relations."

Integrating results from these research efforts can be used to develop application solutions to provide decision support for policymakers.

Biodiversity and ecosystems: Important, innovative, timely and relevant research

Gerber is confident that biodiversity and ecosystems informatics is a future fruitful area of research. She explains why this application of ontologies holds so much promise, "Semantic models with ontologies that capture and reason about meaning can assist scientists to understand the interrelationships of the domains. This has already been done in medical informatics with ontologies such as SNOMED CT1. Knowledge integration between relevant domains at the level of meaning would be very valuable."

Gerber and her colleagues are keen to apply the same scientific rigour to the domains of biodiversity and ecosystems to assist some of South Africa's key researchers at the CSIR and other national institutions. "At present, there is limited use of semantic technology in these domains. Intelligent information systems can add greatly to current efforts to manage these precious resources," she remarks.

Potential impact is envisaged as protection of South Africa's biodiversity heritage to facilitate sustainable development, thereby protecting ecosystems services on which South Africans depend for their livelihood and life services. Ontologies can also facilitate the potential for bioprospecting and assist in the protection of intellectual property.

This will, in turn, boost South Africa's standing as a country with leading research and experts in biodiversity and ecosystems. – Biffy van Rooyen

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Empowering communities to build networks

'Empowering communities to build their own networks'... This is the philosophy that holds firm in the BB4All (Broadband for All) initiative, a joint initiative between the CSIR, the departments of Science and Technology (DST), and Communications.

Some of the Village Operators from the KwaMhlanga area, spent time with the CSIR's ICT experts to get to grips with their new responsibilities

BB4All management team (front row from left): Ajay Makan, Alida Veldsman, Kobus Roux, Neil Oosthuizen Back row: Marlien Herselman, Ronel Smith, Madelein van den Berg, Bonang Tselane, Mario Marais

TO THRIVE IN TODAY'S WORLD, it is important to understand the role ICT plays in society and the development of people. BB4All aims to provide affordable broadband connectivity to under-serviced, rural communities. It uses low-cost infrastructure that is owned and supported by the local community, to create socio-economic and commercial opportunities.

At the heart of the BB4All initiative is the Wireless Mesh Network (WMN) project. It is funded by the European Union through the Sector Budget Support (SBS) programme of DST.

The collaborative project started in 2009, with roll out of a broadband network in the Nkangala Region. The project will in coming months roll out to the Sekhukhune District in the Limpopo Province and the John Taolo Gaetsewe District in the Northern Cape.

The local heroes

The key success factor in this initiative is the Village Operators (VOs), who work within the communities to provide and manage the BB4All network. There are currently 19 VOs working in 15 communities in the Nkangala region. VOs are young local entrepreneurs with a keen interest in ICTs and who want to be self-employed. They are sourced from the targeted communities and will service their own communities.

To date, wireless mesh equipment has been installed in more than 200 facilities and is currently being connected to the Internet. These facilities include 175 schools, school circuit manager offices and a community radio station.

The initiative uses established wireless mesh research and transforms it into an innovative approach to real-life situations. Through this intervention, the improvement of the quality of life of rural or underserviced areas of South Africa has become a possibility.

This project also provides the opportunity for multidisciplinary research where social and business aspects are integrated with technological research to provide a sustainable business model.

The VOs are encouraged through training and mentoring to build and maintain their own businesses. They receive business and basic technical training, which is augmented by training on WMN technology and experiential learning. All these aspects support and encourage self-learning, a key skill for the VOs and communities to be self-sustainable.

The BB4All model learns from other past and current CSIR ICT innovations and models such as Infopreneurs® and the Digital Doorway (see page 44).

Broadened skills base in wireless mesh technology

A local manufacturer has been contracted to manufacture some of the wireless mesh equipment. Parsec manufactures the high performance nodes, a key component in WMN technology. This stimulates the use of locally-manufactured products and local labour. Ingwapele Technologies, headed by Louis Bapela, employs 10 permanent staff members, who are trained to install the nodes and other equipment unique to WMN. This is contributing to broadening the local skills base of the wireless mesh technology and to skills building of these young people.

Sustainability for now and into the future

Through training and development, the BB4All initiative aims to leave a legacy in this community, a business model powerful enough for the community to sustain and develop further. The VOs will be well-equipped with resources, knowledge and the contacts to grow their own businesses, support their community and be the real advocates of ICT.

BB4All is a growing initiative with ambitious goals. At its completion, it will have connected at least 450 facilities (schools, clinics and other government facilities) and developed at least 45 VO businesses. Broadband infrastructure in rural areas will help with access to essential services such as health care and education, and bring other services, such as government services, closer to people. These are communities that were previously almost marginalised due to distance and circumstance. As ICT citizens of the world, they have the potential to become participants in the global information society.

Nombulelo Molumaela, one of the VOs attests, "For me, the BB4All initiative brought a lot of knowledge. I didn't know about broadband and wireless technology; I am now informed and will in turn share this knowledge with my community. In this way I will be adding value to my community just as the initiative has added value to my life."

Another VO, Sibusiso Mazibuko adds, "We (the VOs) wake up every morning to go to the office. You should see Michael Mabena and Innocent Nene going to their office; you would be convinced they are working on Wall Street! Such is the pride we have in this project." – **Bonang Tselane**

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Infopreneur with a rural entrepreneur

Information services to support entrepreneurial development

THE INFOPRENEUR® concept is a rural innovation and development model that guides and supports the establishment of primarily youth-owned social enterprises that form a sustainable, information network. Given its successful track record, the project is now looking forward to collaborating with institutions, individuals or corporations that share its values. These include the 'Ubuntu' approach to business, social entrepreneurship, development through enterprise, virtual and physical networking, effective inquiry, and ICT-promoting culture and community development.

The information networks established by the Infopreneur® concept, help rural communities to overcome the digital divide and challenges related to being 'off the grid'. These challenges include insufficient access to government service delivery; ineffective access to extensive trade opportunities into and out of communities; the absence of access to modern technology, connectivity; and the information that such connectivity would provide. An Infopreneur® is an *information entrepreneur.*

There are currently 20 Infopreneurs® distributed among the Vhembe, Bojanala and Siyanda (Namakwaland) districts. The Infopreneur® project has evolved over the years, from identifying, training and skilling individual Infopreneurs® to assisting them in establishing social enterprises. Infopreneurs® are in the business of collecting information in their communities, to be used by the community and for external parties.

Apart from servicing communities with information, the success of the network is also based on the provision of services to government (provision of data on economic activities), the private sector (a channel to market directly to an informal or previously untapped market) and developing communities (e.g. SME business services) in a development-through-enterprise approach. Research challenges have been in the technology adoption and ownership spheres as well as the twin issues of scalability and sustainability.

As community-based ICT-enabled, sustainable, micro service enterprises, Infopreneurs® act as the steering mechanism that drives community development, by giving community members access to information gathered from different sources, and helping them work with this information.

Infopreneurs® assist with a variety of information. Two current examples are a bee farming project and another is the National Recordal System (see next article).

Hive of information

Infopreneurs® is helping young entrepreneurs establish their own businesses in the bee farming industry. The young businessmen and women will be farming healthy bees from the Kruger Park, harvesting the honey and packing it for sale. Infopreneurs® assist entrepreneurs directly or put them in contact with specialists who will train them in bee keeping, hive management and honey production and marketing. An example of using ICT innovatively in this context is the practice of adding Quick Response (QR) codes on honey labels. These QR codes are readable by a smartphone, and when photographed, direct the enquirer to information provided on the Internet by the entrepreneurs. Information includes the location of the hive, the number of bees in the hive, and the location and origin of the honey. **– Bonang Tselane**

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What is indigenous knowledge?

"The local knowledge that is tacit, expressive and unique to a given culture or society and is the basis of local-level decision-making including, but not limited to agriculture, health care, food preparation, education, natural resource management, economics, governance and security."

Safeguarding the future of indigenous knowledge through ICT

Cultural riches are transferred from one generation to another through indigenous knowledge (IK). Unlike India where IK is documented, for example, South Africa's IK vests largely in oral tradition and is running the risk of becoming extinct as a result of westernisation and urbanisation.

AN EXCITING and challenging initiative to record, preserve, protect and promote South Africa's invaluable wealth of IK is being researched, developed and implemented by the CSIR on behalf of and in close collaboration with the Department of Science and Technology's (DST's) National Indigenous Knowledge Systems Office (NIKSO).

Dr Yonah Seleti (DST NIKSO), Carol van Wyk (DST NIKSO), Riëtte Pretorius, Hennie Bezuidenhout (both CSIR)

Implementing the national IKS policy

The National Recordal System (NRS) initiative, spearheaded by Dr Yonah Seleti, Chief Director of NIKSO, supports communities, guilds and other IK holders in recording their IK with the ultimate aim to create opportunities for benefits to flow back to the communities. These benefits may include both social and economic benefits.

The NRS implementation encompasses the establishment of IK Networks, IK documentation centres and an ICT knowledge platform, all of which will be strengthened by appropriate processes and stakeholder involvement to achieve the aims encapsulated in the IKS policy.

In addition, the initiative aims to bring selected fragmented databases together through a portal to enhance the National System of Innovation for research and development purposes within the national priorities of the DST.

Innovative and new technologies will be introduced to facilitate the NRS's aim to collect un-captured IK (traditionally transferred from one generation to another in an oral and tacit format) in multimedia without losing too much of the contextual information. New and/or enhanced existing processes and systems will respect the cultural, traditional customs and etiquette of IK holders and communities while capturing, managing, storing, protecting and responsibly publishing IK information.

NIKMAS: the digital brain of the NRS

In support of the NRS initiative, the National Indigenous Knowledge Management System (NIKMAS) will be a semantic digital repository to be used as the technology platform that will, among others, manage prior art declaration.

NIKMAS is being developed in parallel with the IK collection activity in the communities, in order to support the new processes and requirements identified and developed by and within the communities. Although the development of NIKMAS poses several significant technical challenges, it has the potential to be the leading IK management system both nationally and internationally.

NIKMAS is far more than just a catalogue of IK resources, the CSIR NRS project leader Hennie Bezuidenhout explains, "NIKMAS will be an intelligent knowledge repository." It comprises a semantic digital repository with custom-developed meta data schemata and a sophisticated security model to protect and preserve the IK, an advanced semantic search engine, a sophisticated cataloguing system and an overarching integration architecture that combines the subsystems into a coherent, fit-for-purpose system.

Intelligent reasoning through ontology research on IK-related meta data will be encapsulated in the design and development of NIKMAS. Ronell Alberts, a CSIR researcher studying towards her MSc at the Free University of Bolzen-Bolzano in Italy will complement this ambitious and novel system by focusing her studies on the use of ontologies and semantic web technologies for intelligent searching, specifically on indigenous knowledge.

The first version of NIKMAS will focus on the African Traditional Medicine and Indigenous Foods themes as dictated by the national priorities of the DST. Other themes will be prioritised and implemented together with the appropriate stakeholders over the next two years. It is envisaged that NIKMAS will provide significant social and scientific benefits to communities and researchers alike.

IK networks and centres

The recordal of IK is a complex process requiring a two-pronged approach: The cataloguing of IK holders (who, what and where) and the actual recording of knowledge.

According to Carol van Wyk, DST Deputy Director: Knowledge Management, much of South African IK is still in oral format and by establishing IKS Documentation Centres (IKSDCs), the department's aim is to effectively enable and to facilitate the collection of IK within communities by communities, to be captured in NIKMAS for the primary benefit of community and research opportunity within the National System of Innovation. The IKSDCs are viewed as pillars for the NRS in local and indigenous communities. Two complementary models (i.e. community networks and IKSDCs) are currently being tested in the communities to define an appropriate model for the recording of indigenous knowledge.

"NRS is envisioned as the leading indigenous knowledge systems treasure hub for South Africa's communal socio-economic development."

IK is being recorded through pilot networks in the provinces of Limpopo, North West and the Eastern Cape. Through these pilot networks, recording systems and processes are tested and refined in a Living Lab context. In addition, community members are sourced and skilled to act as IK recorders to collect information from their community members.

At present there is one pilot IKSDC at the University of Zululand (UniZulu). This pilot is being used to test and scope the ideal IKSDC. This and future pilots will be implemented and tested by NIKSO.

Giving back to communities

An action-based research methodology was adopted to allow for consistent and continuous learning from and for the communities. CSIR researcher Riette Pretorius points out, "Communities are guided and supported to structure themselves. They are skilled and trained to develop business plans, and on how to use various ICT and other electronic equipment, for example, cameras and global positioning system devices." Pretorius continues, "Above all, through guidance by NIKSO, they are informed of their rights and taught that their rights are protected through various legal documents that form part of the IK recording process such as memorandums of agreement, prior informed consent, information transfer agreements and non-disclosure agreements."

Bezuidenhout confirms, "Our approach ensures practical measures for IK holders and practitioners to develop services with a particular focus on IKS with a scientific base."

Responsible exploitation

As part of the envisaged value chain and to ensure that social and economic benefits accrue to the IK owners (communities and IK holders), all captured IK data will be securely stored in NIKMAS with appropriate security control mechanisms to manage access to information. Pretorius reveals, "Intellectual property policies, procedures and processes developed by the relevant authorities will drive the protection and exploitation of IK, while NIKMAS will secure the IK knowledge captured."

Ultimately, the NRS will provide a structured process by which culture can be promoted, sustainable livelihoods supported and knowledge shared. – Biffy van Rooyen

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SAGrid enthusiasts: Dr Bruce Becker, Albert van Eck (Deputy Director: IT, Free State University) and Christiaan Kuun (SANReN project manager at the CSIR)

Today's research is overwhelmingly digital – whether it is related to data or computing or any combination of such services in a collaboration.

Making the most of infrastructure: **The role of the SAGrid**

SOUTH AFRICA'S investment in e-infrastructure acknowledges the increasingly digital nature of the research and has put in place a systematic way of addressing the challenges of e-Science, through large investments such as the South African National Research Network and the Centre for High Performance Computing (CHPC). Building on these, a federation has been formed by most of South Africa's top universities, national laboratories and research groups, to provide a framework for collaboration. The South African National Grid (SAGrid) provides a coherent platform for the integration of computing resources, but also human networks, such as technical experts and scientific collaborations within South Africa's borders and well beyond, encouraging the full utilisation of this common investment.

The investments made so far by the Department of Science and Technology (DST) – SANReN (see page 30), the CHPC and the upcoming initiative to curate large data sets – has unlocked a certain amount of potential in scientific and industrial advancement, bringing to certain parts of the research community tools which they would not previously have had. SANReN has certainly proven a game-changer in this respect, bringing about a potential sea change in the way that people work and communicate. With institutes on the network deploying, integrating and jointly managing compute resources, the full potential of the network is unlocked.

Dr Bruce Becker is responsible for the SAGrid which is managed from the CSIR. He explains how the SAGrid encourages full use of the benefits of South Africa's cyberinfrastructure to the benefits of all sub-groups and individuals. "This has had huge benefits to several research communities, in terms of efficiency, collaboration, cost-effectiveness, competitiveness, and scale," Becker says. "It is the means by which geography and institutional capacity are no longer factors in perpetuating inequalities, but become accessible to all researchers who may use them to their own competitive advantages."

The fundamental aspect of the grid is that it provides a coherent interface to a vast array of services for users. These include the traditional HPC services as well as the well-known high-throughput and high-capacity computing, but extend to data curation; data management and movement; metadata catalogues; identity; and security services. High-level services such as workflow engines, compute agents, software management, monitoring, accounting and collaboration services are also a fundamental part of the grid. Another defining feature is that no matter where the particular resource is or what its physical details, the user and application can always interact with the service in a standard way.

"This also means that we can share our infrastructure and services with other similar initiatives in the world, opening up vast opportunities for collaboration. Recently, such integration has been done with the sites in North Africa, with a Memorandum of Understanding (MoU) with the EUMed-Support project, and a similar MoU will soon be signed with the European Grid Infrastructure as well as the GISELA project in Latin America. These infrastructure sharing agreements of course mean that all South African researchers have access to not only incredible compute power, but it gets better: the human networks built by these technical collaborations mean that user and application support, training and application porting are part of the package. So, no matter where users are or with whom they are working, we can use a common platform to support them and their applications. The benefits of this are manifest and will soon be felt by several institutes in Africa where new sites and applications will come on board," Becker states.

SAGrid provides all of the services necessary to conduct science for the 21st century. It is open to all resource providers and users. Visit www.sagrid.ac.za to find out more. – **Biffy van Rooyen**

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An African **e-infrastructure**

The CSIR places a very high premium on collaboration and human capital development at all levels of research, from the high school all the way through to the laboratory. This is evidenced by its involvement in two projects which have recently made headlines, both sponsored by Hewlett-Packard (HP) Corporation's Global Social Innovation Office.

Deputy Director: IT from Free State University, Albert van Eck (seated) and the CSIR's Dr Bruce Becker

The time is now ripe for an African e-Infrastructure that would help provide African solutions to African problems for the overall development of the continent.

The Brain Gain Initiative

The Brain Gain Initiative (BGI) started with a pilot project in 2008, and is now in its second year of activity. Managed by UNESCO, the project aims to provide a bulwark to the crippling brain drain experienced by Africa. This is done by creating research and collaboration opportunities to African diaspora, through the power of grid computing.

The CSIR is involved in the project through the South African National Grid (SAGrid) which provides technical support and coordination to this project. The members of this project represent some of the best research groups from the continent and the selected research projects range from air quality to e-waste management. All of them have a strong need for e-Infrastructure.

This is where SAGrid (see page 27) comes in. In collaboration with the EGEE (Enabling Grids for E-sciencE) project (now evolved into EGI (European Grid Initiative)), SAGrid has provided training, technical support and operational support to the project itself, as well as to the individual participants. The CSIR's Dr Bruce Becker who coordinates the SAGrid, comments, "With the start of the CHAIN (Co-ordination and Harmonisation of Advanced e-Infrastructures) project and the development of the AfricaGrid Regional Operations Centre, we are starting to see many more sites coming onto the grid.

"While SAGrid is coordinated from the CSIR and one of the sites on the grid is actually hosted at the CSIR (ZA-CSIR-C4), it is the national operations team – consisting of the IT experts at the various sites who form the federation – which is the real power behind the grid.

As the technical partner to the BGI, Becker was tasked to provide training to a user group (scientists who would be using the grid nodes for research) and a technical group (who will be required to operate the grid nodes). Joining him on the SAGrid team of trainers were Albert van Eck, Deputy Director: IT at the University of Free State, and Dr Valeria Ardizzone, an expert in grid computing from the INFN (Instituto Nazionale di Fisica Nucleare) in Italy, and technical coordinator of the DECIDE (Diagnostic Enhancement of Confidence by an International Distri-

in the making

Adele Botha is part of the New Learner consortium (led by the Agastya Foundationin India) of the Catalyst Initiative. She is working on a peer-learning system – one of the outcomes of the project

Team members of the Brain Gain Initiative

buted Environment) project, who has been working with Becker since the inception of SAGrid in 2008.

"During the training session, the GridOps team has proved its worth by not only running some of the training sessions for the 38 participants, but also ensuring that the various services were in perfect order, and coordinating the deployment of new sites across the continent.

"Thanks to the knowledge transfer enabled by SAGrid, some of the experts at these new sites will in turn provide manpower to the regional operations team, thereby increasing the capacity of the grid and ensuring uptake and sustainability of the infrastructure."

Marc Bellon and Liliana Simionescu of UNESCO were responsible for the BGI project planning of the Pretoria event. This follows on from an earlier African pilot project. Bellon commented, "The willingness to learn among the group of African researchers was matched by the acquisition of new skills. Similarly, we are pleased that the understanding of the technical group has been enhanced through new and useful information."

HP Catalyst Initiative

The second project that the CSIR is involved in is the Catalyst Initiative, a global network of consortia that brings together leading educational institutions and NGOs, to explore new approaches to science, technology, engineering and math (STEM) education.

In 2010, the CSIR Meraka Institute was awarded a grant as the leader of the Global Collaboratory consortium, one of the HP Catalyst Initiative's innovation themes. The Global Collaboratory unites the facilities, minds and skills of Cairo University, Faculty of Computers and Information (Giza, Egypt); Coventry University (Coventry, UK); Del Mar College (Corpus Christi, Texas, USA); East Carolina University (Greenville, North Carolina, USA); Masinde Muliro University of Science and Technology (Kakamega, Kenya) and Stamford Public Schools (Stamford, Connecticut, USA).

This collaboratory enables students to participate in collaborative problem-solving to address urgent social challenges using the power of collaborative grid computing. Becker points out, "The collaboratory links almost all of the human components of a healthy research environment, all the way from the learner, through the teacher, to the researcher. It brings to the environment state-of-the-art infrastructure and resources, which can be incorporated in the research and learning experience. By ensuring that these are relevant in the learning experience, we are preparing the students for a life in research, which is a very strong determining factor in a country's economy."

Several other South African institutions are active in the HP Catalyst Initiative, notably Nelson Mandela Metropolitan University, University of KwaZulu-Natal and North-West University.

New opportunities and challenges

Becker sees new and interesting challenges ahead for the HP Catalyst and BGI, "While working at the CSIR, we put the finishing touches on the sites in Senegal and Morocco which are now online and in the process of being integrated. In the coming months, we will be doing training and conducting scientific workshops in several key countries. I will be hosted by the Ecole Nationale des Sciences de l'Informatique in Tunis where we will run a scientific workshop for distributed computing, together with UTIC (Unité de recherche en Technologies de l'Information et de la Communication).

The Brain Gain Initiative will deliver a durable, valuable asset – an infrastructure and a community of users.

"The SAGrid core services team from the University of Cape Town's Information and Communications Services department will be going to Kakamega and Nairobi in May 2011 on invitation to finish the integration and run dissemination workshops with the vice-chancellors of their respective universities." – **Biffy van Rooyen**

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The SANReN team of the CSIR: (Front) Prof Colin Wright, Simeon Miteff, John Hay, Thabo Koeshe and Christiaan Kuun (Second row) Zukisani Makalima, Uli Horn and Geoff Daniell

Unlocking the potential of **research networking**

THE SOUTH AFRICAN National Research Network (SANReN) has achieved significant milestones in its implementation of a research network for South Africa. Its latest achievement has been the completion of the Durban metropolitan network and the Pretoria DWDM (dense wavelength division multiplexing) ring.

The intervention is rapidly reaching its chief objective which is to connect research and higher education institutions (HEIs) in Pretoria, Johannesburg, Bloemfontein, Cape Town, Port Elizabeth, East London, Durban and elsewhere in the country on a 10Gbps (Gigabits per second) optic fibre ring network.

This network will enable the research community to engage in meaningful online collaboration. It will be used to link to international bandwidth acquired for research purposes.

A sea change in connectivity

Why is SANReN set to change the research landscape in South Africa radically? Prof Colin Wright who leads the SANReN team, explains, "SANReN increases local bandwidth for its users and provides them with international bandwidth at an affordable rate. It makes for better spending of financial resources.

"By providing research networking to South African research and HEIs, we help these institutions free up funds that might otherwise have been spent on purchasing bandwidth for researchers."

TENET was responsible for negotiating a good price for 10 Gbps capacity on SEACOM, a fibre optic cable providing high capacity bandwidth to southern Africa, East Africa, Europe and South Asia. This is distributed through SANReN which integrates the availability of the local and international bandwidth. Geographically diverse routes are currently being investigated by TENET for redundancy of bandwidth.

Another benefit of SANReN – with profound indirect future impact – is the uptake by a generation of new researchers of the benefits offered by improved bandwidth for research traffic. Bandwidth abundance resulting from SANReN's networking of universities has the potential to shape the growth and development of a new generation of students whose knowledge and skills will contribute to the goal of creating an inclusive information society. This in turn will enable socioeconomic benefits through information and communications technology – specifically broadband.

In turn, these advances on the scientific front will contribute to the competitiveness of local industry through the scientific breakthroughs achieved and through the establishment of the world-class national cyberinfrastructure.

Bandwidth ups the ante for astronomy and space science

To date, SANReN has helped to ensure that South Africa takes its rightful place among its peers in the radio astronomy in terms of VLBI data provision to the Joint Institute for VLBI in Europe. Data on radiation from space are gathered at HartRAO, the only radio astronomy facility in South Africa, and are sent to Dwingeloo in the Netherlands. "South Africa is therefore able to take its place in the international radio astronomy experiments," confirms Wright.

TIMELINE

2003
Conceptualisation in partnership with the then Department of Arts, Culture, Science and Technology (DACST)

2006
Research infrastructure becomes DST budget item

Contract between DST and the CSIR

2007
National implementation phase commences

2008
National research cyber-infrastructure live in Gauteng

CSIR SANReN steering committee members Laurens Cloete and Johan le Roux

FAST FACTS

SANReN is part of the national cyberinfrastructure initiative. It complements the Centre for High Performance Computing and the Very Large Datasets curation project

Function:
To provide networking and network services to research and higher education institutions

Funder:
Department of Science and Technology

Implementer:
CSIR, as a strategic initiative

Partner:
Tertiary Education Network (TENET) operates the SANReN network

The aim of these experiments is to use correlation of VLBI data to establish a picture of the planets.

SANReN connectivity will ensure that South Africa has the requisite bandwidth to tackle the Square Kilometre Array (SKA) telescope project. The SKA is set to revolutionise radio astronomy. This new generation astronomical facility promises a larger radio wave collecting area than any other facility in the world; it will be 50 times more sensitive and able to survey the sky 10 000 faster than any other imaging radio telescope array.

South Africa's own microsatellite, SumbandilaSAT, also benefits from SANReN's capabilities. Data are downloaded by the CSIR Satellite Applications Centre and sent to Sunspace in Stellenbosch. Receiving information in a short space of time enables engineers to make the necessary adjustments to the microsatellite for its optimal performance.

Value additions

SANReN has successfully concluded a South Africa eduroam pilot to allow local researchers and staff from participating institutions to access the Internet while visiting another participating institution via wireless hot-spots.

'eduroam' is a worldwide roaming service. Through the use of RADIUS proxies, eduroam allows logging on using the credentials from home institutions, regardless of the institution being visited. SANReN began the pilot in 2010 to establish the proxies required for local institutions to participate. Several institutions participated in the pilot.

In February 2011, the SANReN eduroam RADIUS proxies were connected to the European eduroam root. This temporary connection allows for global testing of eduroam in South Africa, in anticipation of the establishment of an African eduroam root. Visitors to South Africa can use eduroam at all eduroam-enabled institutions. Additional future services for user participation are being developed.

What's next?

The SANReN team will continue to roll out the network to reach all higher education and research sites throughout the country. At the moment focus is applied on extending the network to rural sites, ensuring that 'no one gets left behind'. The SANReN team will seek to secure a national dark-fibre network, as such a network will provide for almost limitless national bandwidth, as well as long-term bandwidth security for the research and education community.

It will also become involved in assisting with the adoption of new network technologies in South Africa by using its fibre networks to test equipment capable of 40-100 Gbps speeds per wavelength. This will be of benefit to the community since the learning obtained can be used to build the next generation of the SANReN network.

In addition, the team will focus on providing more services through the network similar to eduroam. It will ensure that the network can be used to provide maximum benefit to its users by supporting services such as data recovery sites, cloud services, video conferencing platforms and e-learning, to name just a few. – **Biffy van Rooyen**

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2009
National research network tender to Telkom

National backbone network completed

2010
Planned connection to SALT and SKA

2011
Pretoria DWDM ring network goes live

SAFIPA's curtain drawing

THE INTER-GOVERNMENTAL agreement signed by the Department of Science and Technology (DST) and the Finnish Ministry of Foreign Affairs in July 2007 is drawing to a close. The South Africa-Finland Knowledge Partnership on ICT (SAFIPA) kicked off its programme in June 2008 with the objective of supporting the creation of an environment conducive to the development and deployment of ICT service applications for South Africans.

The programme, which is managed by the CSIR on behalf of the DST, had three strategic goals: human capital development; technology research and innovation enhancement.

SAFIPA is now in its final year. Kristiina Lähde, chief technical advisor, and Thiru Swettenham, SAFIPA national programme coordinator, say that in terms of its main three goals the programme has been 'quite successful'.

With great success comes great responsibilities

Says Lähde: "Our success has brought about some new challenges in that our stakeholders want to know who will continue with the good work that SAFIPA has done." She adds that as the programme nears completion, one of the main priorities that emerged is to find a local organisation that will adopt and replicate some of SAFIPA's projects.

"Some of the projects are simpler than others, for example we've developed a training programme for ICT and mobile entrepreneurs; these have been well received. To adopt and replicate such a programme is easier than finding an organisation to provide a similar grant fund to SAFIPA's."

For operational and grant funding purposes, the SAFIPA programme received R3 million from the Finnish Ministry of Foreign Affairs, and R9 million from South Africa's DST. In order to solve the challenges that have arisen due to SAFIPA's success, the steering committee and supervisory board and the two governments have agreed to extend the programme to December 2011.

The three components of SAFIPA's programme

To achieve the overall objective of the SAFIPA programme, three interdependent components were designed.

Institutional capacity-development

Capacity building involved value added instruction, the training of trainers, activities with multiplier effects, and networking. It also involved institutional and human capacity-building.

Innovative IT applications and new solutions for end users

The projects identified addressed education, learning sector and societal development issues such as empowering disabled and aging populations. All of these had specific human capital development outputs among the target constituency.

The sustainability of the solution delivered was considered very important and hence special attention was attached to the identification of the institutional education and learning outputs. This component had two elements: selection, upgrading and implementation of the projects already identified; and identification and preparation of new projects and stakeholder groups.

Network creation and dissemination

Component 3 aimed to strengthen cooperation between research institutions both locally and globally, as well as to support public-private partnerships in the service delivery process.

For dissemination purposes, the programme organised or supported an annual international conference together with relevant programme stakeholders such as universities, companies and communities to inform programme results, innovate new development activities, and promote networking.

Recognition where it is due

SAFIPA-supported projects have since caught the eye of the National Science and Technology Forum (NSTF). As a result, SAFIPA-supported projects have been nominated in two categories of the NSTF awards: 'Research leading to Innovation by Teams or Individuals through Organisations' and 'Communication for Outreach and Creating Awareness of Science, Engineering, Technology or Innovation'.– **Bandile Sikwane**

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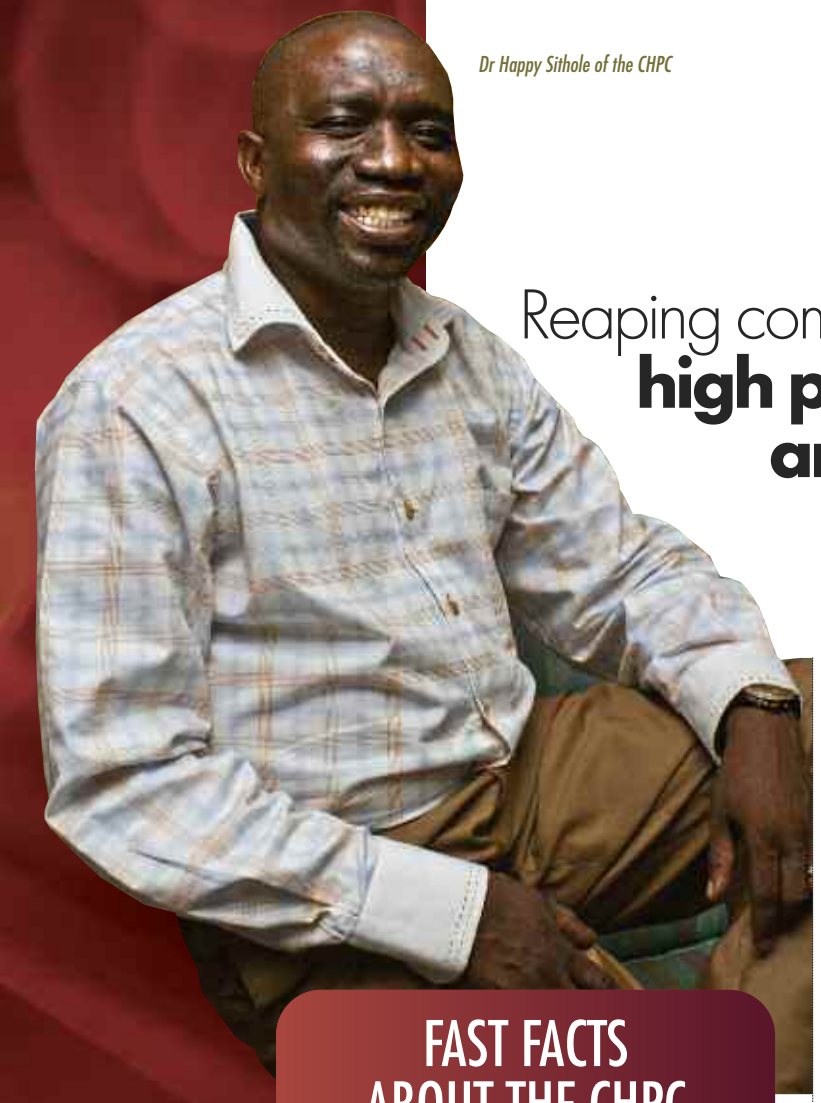
Kristiina Lähde and Thiru Swettenham



Dr Happy Sithole of the CHPC

Reaping competitive advantage through **high performance computing and data curation**

High performance computing (HPC) has been described as the Ferrari of the computing world – elegant, powerful and very, very fast. Thanks to the investment by the Department of Science and Technology (DST) in the national Centre for High Performance Computing (CHPC) as part of the national infrastructure, these benefits are now available to South African industry, academia and science councils. The CHPC is based in Cape Town, with director Dr Happy Sithole at the helm.

FAST FACTS ABOUT THE CHPC

- Launched in 2007
- Provides users with access to Sun Microsystems; Blue Gene/P & iQudu
- Houses the fastest supercomputer in Africa
- Has an extensive human capital development programme in collaboration with AIMS, South African universities and European & African partners

HPC LIES IN THE SPECIALIST domain where cutting-edge computing equipment and associated software components – predominantly open source in nature – come together to push the boundaries of what can be achieved in terms of processing, networking, storage and visualisation.

"Supercomputers help us solve problems today instead of tomorrow," states Sithole. "Their ability to perform computations very rapidly and handle extremely large volumes of data effectively makes them invaluable for research projects where large volumes of data must be processed."

This particular class of problems requires semi-infinite computing resources. The possibility to simulate and model results is the most important advantage that supercomputers have. This in turn supports industrial competitiveness, which depends to a large measure on planning for the future today – and well-established industrial competitiveness is a precondition for economic growth.

Using HPC to achieve national benefits

Through its flagship programme, the CHPC has enabled researchers and industry participants to achieve results in selected fields of application. Although these fields of study and application range from astronomy and aeronautics to electronic engineering applica-

tions and oceanography, several stand out for the novelty of the HPC application and the potential for HPC to achieve results in these priority areas.

Energy storage materials

The increasing scarcity of fossil fuels and their soaring cost have necessitated and accelerated the search for alternative energy sources. A flagship project led by Prof Phuti Ngoepe of the University of Limpopo used computational modelling techniques on the CHPC's IBM cluster to complement experimental approaches in the study of high-power lithium ion rechargeable batteries for cars and renewable energy resources.

The work focused on the simulation of the complex microstructure of lithium manganese oxide (low cost, environmentally-inoffensive and with high energy density material) for use in high capacity composite electrodes. These simulations have laid the foundation for modelling current and future battery compounds of interest, particularly those microstructures used to predict vehicle performance.

Ngoepe's group engaged with Optimal Energy, responsible for the manufacture of the first electronic vehicle in South Africa. The group has assisted with battery testing and battery choice for the prototypes that preceded Joule, South Africa's first electric car.

Computational biomechanics

In a research effort to understand the mechanics of the heart, a group of biomechanical scientists at the University of Cape Town is also using the power of HPC. Led by Dr Thomas Franz, researchers and students are modelling the behaviour of the mechanics of the heart on the CHPC facilities – with and without the addition of a plastic and chemical compound used to repair weakened heart muscles.

This synthetic polyethylene glycol hydrogel is being investigated by Dr Neil Davies of the Cardiovascular Research Unit to build up heart walls following a heart attack. After it has been injected, the hydrogel forms a web-like substance throughout the damaged tissue. By comparing the behaviour of the heart mechanics, it becomes possible to isolate other factors that may be playing a role in the heart repair process.

This is the second CHPC flagship in life sciences, a trend that is likely to continue as studies in life sciences have the potential to impact positively on the population at large.

Creating art with HPC

South Africa's first full-length animated movie by Character Matters, 'The Lion of Judah', hit the screen in September 2010. The facilities of the CHPC were used to produce it.

South Africa has now joined other countries, such as New Zealand, where HPC facilities are used for movie-making. The CHPC was able to assist Character Matters with the rendering of the movie, which requires working with huge volumes – 25 terabytes – of data. These data are needed for the virtual production of animated movies.

"We hope to assist aspiring South African filmmakers by providing access to our facilities," Sithole states.

He confirms that apart from these applications in energy, medicine and the animation industry, other opportunities abound for the CHPC to support the competitiveness of other industries, such as the local petrochemical industry, as well as the financial sector.

Data curation

The Very Large Database (VLDB) initiative, the third leg of the national cyberinfrastructure investment by the DST, envisages the storage and curation of research data from all research domains, particularly in areas of environmental and climate change modelling, bioinformatics, medical sciences and astronomy. "Providing large data repository and curatorship platforms enable sustainable knowledge sharing and other benefits for cyberinfrastructure," Sithole points out.

Implementation of the VLDB initiative takes place in consultation with stakeholders who manage important research data. As part of the pilot of phase 1, the following organisations have been brought on board: the Human Sciences Research Council (HSRC), the Square Kilometre Array (SKA), the South African Astronomical Observatory (SAAO), and the South African Environmental Observation Network (SAEON).

Once the data repository has been commissioned and tested, the second phase will commence during the 2011/2012 financial year. Sithole explains, "All other stakeholders with important research data will be encouraged to participate." The storage will be a fully-redundant, reliable system with capacity to spare, and will be replicated at two sites: Cape Town and Pretoria. – **Biffy van Rooyen**

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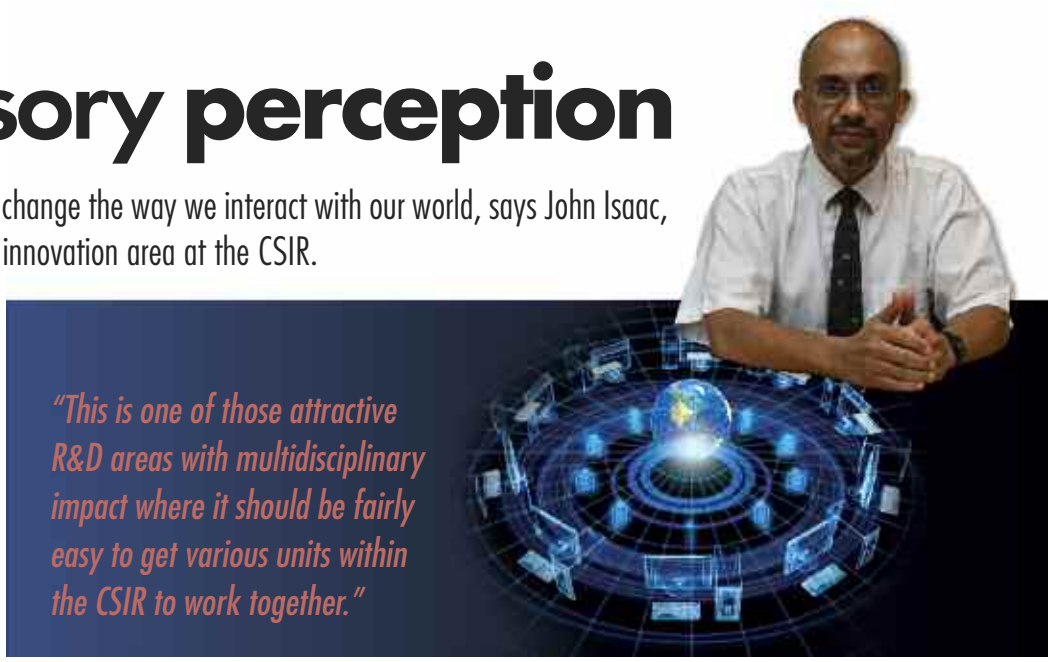
"The DST's ICT intervention aims for unlimited processing power, bandwidth and storage. We are gradually becoming a destination of choice for high performance computing, attracting some of the best minds in cyberinfrastructure."
– Mrs Naledi Pandor,
Minister of Science and Technology

Extra **sensory perception**

Advanced sensor networks can change the way we interact with our world, says John Isaac, lead member of this emerging innovation area at the CSIR.



IMAGINE THERE WAS A WAY of intervening in a potential electricity cable theft before the crime happened, or a way of knowing well in advance that a mains water pipe in a suburb was about to burst? Imagine that traffic lights knew you were the only car driving through some intersection on a late Saturday night and helped you on your way?

The types of technology challenges associated with the above scenarios are what engineers and computer scientists at the CSIR's newly-created area on Advanced Sensor Networks (ASN) are interested in solving.

The area was established in September 2010. However, John Isaac, ASN's lead, lets on that the establishment of a research group was mooted as early as 2008. "We initially planned to start a joint research group with the University of Pretoria (UP) under the digital@SERA collaboration, but this did not happen quite as we envisaged. Instead, there is currently an ASN initiative at UP and one at the CSIR that are working closely together with various joint activities," he explains.

In preparation for the joint initiative on ASN, Prof Ian Akyildiz of the Georgia Institute of Technology was appointed as an Honorary Professor at UP's Department of Electrical, Electronic and Computer Engineering.

"In Akyildiz, we have access to a world authority in ASN who has really helped define the field. He is very excited and very determined to work with us," says Isaac. "He has made his resources and his worldwide network available to us. We have embraced him as part of the fabric here at the CSIR," he quips.

"This is one of those attractive R&D areas with multidisciplinary impact where it should be fairly easy to get various units within the CSIR to work together."

What are advanced sensor networks?

In his 2002 article, which has been cited over 12 000 times, Akyildiz explains that a sensor network is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. Cheap, smart devices with multiple onboard sensors, can be networked and deployed in large numbers, he says. These can provide unprecedented opportunities for instrumenting for monitoring and control of homes, cities and the environment. According to Akyildiz, the position of the sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operations.

Isaac agrees and emphasises that an important aspect of advanced sensor networks is that the sensors are 'smart' (i.e. have computational capabilities to make local decisions/actions) and the network technologies connecting these sensors also have some special features that in combination allow for the intelligence distributed in the sensor nodes to be utilised to cooperatively carry out tasks even without human intervention. Thus, advanced sensor networks allows smart systems to be created that can sense, decide and act autonomously or with some added human direction.

Building an industry

One focus of the ASN initiative, says Isaac, is on the uses of ASN for electrical utilities for monitoring, control and protection including in extreme and hazardous environments. Other areas of interest are underground, underwater and multimedia sensor networks with applications ranging from agriculture to mining to environmental monitoring.
Isaac says that the main aim of the ASN initiative is to give the economy a boost, "We work in an area where we can stimulate industry." He notes, however, that ASN is still an emerging concept in the country, "We find that, at the moment, the market is not that well-educated on what is possible with advanced sensors."

He states that to stimulate the economy, the ASN initiative will play a strategic role. "We want to get a national conversation going around the many possibilities that ASN brings. All of this means that we have to talk to a whole lot of small to medium-sized enterprises and technology vendors. We have to bring in the universities and create R&D backing capacity at universities and the CSIR in this field." Isaac believes South Africa is well-poised to build its own industrial capabilities around advanced sensor networks. "South Africa is not that far off to the rest of the developed world," he says. "We have the advantage that we are still building our infrastructure, thus while we are fixing water pipes and installing cables, we can also embed advanced sensors," he adds.

One of the most exciting fields

Isaac states that ASN is an exciting field that opens up many opportunities for collaboration between industry, academia and the CSIR. "This is one of those attractive R&D areas with multidisciplinary impact where it should be fairly easy to get various units within the CSIR to work together," he states. "There is something for everyone in ASN. For those who want to publish, there is a lot of research to be done. For industry and others with a profit motive, there are many applications and solutions that can be built and exploited for profit," he says. "When all is said, the most important thing is that we have an amazing opportunity to create an industry," Isaac concludes.

– Bandile Sikwane

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community Internet television – live broadcasting for the masses

WHO IS INVOLVED?

In 2009, the CSIR's real-time video coding research group received an investment from the Innovation Fund at the Department of Science and Technology to form a consortium with a Durban-based Black Economic Empowerment company, East Coast Access, and the University of Cape Town.

LIVE TELEVISION broadcasting over the public Internet is not a new idea, but it is one that has been almost impossible to accomplish in developing countries up until now. That is because different areas and people have access to different bandwidths, making the quality of the broadcast feed unstable and irritating to watch.

In developing countries access to broadband services are few and far between. Researchers at the CSIR, University of Cape Town and East Coast Access have come up with a solution for this problem that will soon be put through its paces in a pilot study by a local radio station. It is called the ARTIST project, short for Adaptive Real-Time Internet Streaming Technology, where local and international patents on the technology have been filed.

The competitive edge

Dr Keith Ferguson of the CSIR's Real-Time Video Coding research group explains: "Our invention allows for anyone and anywhere to set up an online television station of their own, derive revenue and create job opportunities from it. What gives our technology the competitive edge is the fact that the quality of the image is adaptable to the quality of the infrastructure, making it ideal for low bit-rate situations such as is mostly experienced in developing countries."

Imagine watching a live broadcast of a world-altering, breaking news story; or a sports game; or a music show; without the constant buffering or delayed transmission and while only having access to a slow Internet connection. Ferguson is adamant: "With live broadcasts, buffering and delays are simply not allowed!"

He mentions that they want to broadcast African creativity with this technology. "We don't fully know yet what can be done with it," he says, referring to the fact that, as engineers, they cannot even begin to imagine the creative spectrum thereof. "The possibilities are endless, and we cannot wait to put it into the hands of communities and see how creative they can be."

A radio community as the pilot

The first community that will be participating in ARTIST's pilot is a local commercial radio station with an audience of just over 1.4 million listeners. The station is based in Johannesburg.

"For us it was important to pilot the technology with someone where we would be able to be physically present to sort out any glitches. The location of the station and community demographic fitted the bill perfectly."

According to Ferguson, the purpose of the pilot is not only to test the technical ability of the technology in a real-world situation, but to also test its commercial viability

The CSIR's Real-Time Video Coding research group includes, from left, Dhiren Seetharam, Nakato Kakande, Louis Joubert, Dr Keith Ferguson, Veronica Sentongo and Ralf Globisch. Absent from the picture is Marde Helbig.

What did the research and development of ARTIST entail?

To broadcast live video over the Internet requires designing massively scalable systems that can cope with hundreds of thousands of simultaneous viewers and deliver appropriate advertising to each unique viewer.

The group's research, development and commercialisation agenda spanned the modelling of network behaviour under congested conditions, video encoding and optimisation techniques, massively scalable architectures for commercial-grade video delivery and built-in new media advertising models.

and possible commercial models – that is, whether advertisers will be willing to use this medium to deliver their message.

"Through the technology the radio station is given an opportunity to broaden the scope of its website by attracting more of their listeners. New, innovative ways of online advertising then becomes available. It also opens up branding opportunities for companies or organisations.

The pilot radio station, for instance, is planning to actively promote its listeners to also become viewers and to change its style of presentation to be more visually interesting through the live video streaming on its website," he comments.

Peer-to-peer video conferencing protocol standardisation

Linked to the ARTIST project is another from the same group of researchers that involves high-end, high-definition live video conferencing over the Internet. "Imagine video conferencing with several people at the same time, all in high-definition," says Ferguson.

With this peer-to-peer protocol project, the group aims to build an international profile by contributing to the standardisation of peer-to-peer video conferencing-related protocols. They are working with Berlin-based Fraunhofer's Institute for Telecommunications, the Heinrich Hertz Institute.

Catering for the lower end of the market

A third project revolves around low bit-rate video coding for applications in developing countries. "Developed countries," says Ferguson, "are not primarily interested in low-definition coding. They mainly concentrate on improving the envelope for high-definition. The reality in the developing world, however, is limited Internet communication infrastructure which will still be around for many years to come."

The aim of this project is to extend the lower range of the international video-coding standards to enhance the picture quality at the low bit-rate end of the market.

Ferguson explains: "The quality of your Internet connectivity changes as you move around on a mobile device or as more people share the same bandwidth and so on. With this project, we aim to adaptively maximise the picture quality for the given bit-rate that your client device experiences at any given moment in time."

He says that if one can track the ups and downs of their connectivity then they can encode the video to match the feed that you receive. "You need to be able to move in and out of different bandwidths all the time while still providing the best perceived viewing quality; and this is what we aim to achieve."

Funding to commercialise

For now, all eyes are on the ARTIST pilot project with its radio station pilot. If the technology proves to be successful and the commercial models viable, the team will need funding to take it further into the market.

"The world is our oyster with this technology. We have already had massive interest from various 'communities' who want to use it. Hopefully, it will bring live, quality broadcasts into the homes and offices of millions of people in developing countries and, at the same time, take on the mobile developed world," Ferguson concludes. – **Petro Lowies**

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mLabs: Empowering through locally-developed

mLab = Regional Mobile Applications Laboratory

"Phones are inherently social devices and the industry is just beginning to discover what's possible," said Facebook boss Mark Zuckerberg at the Mobile World Congress in Barcelona, Spain in February 2011. He was responding to rumours that the company is planning to launch its own mobile phone, and made it clear that they would rather invest in the development of mobile applications (m-apps) than physical handsets.

While social networking is just one type of m-app that has already taken the world by storm, the fact remains that mobile phones have the ability to connect the unconnected to the World Wide Web and to do so in ways we can only begin to imagine.

A technology boom in the making

"The m-apps environment is at an early stage of a profoundly important movement toward establishing the next dominant global information platform, and especially in the developing world," says Ben Zaaiman, programme leader of the CSIR Meraka Institute-led mLab. If statistics are anything to go by, then he is right on the money.

There are approximately 450 million mobile subscribers in Africa, which represents a market penetration of 50%. The World Bank (WB) estimates that in this region, a further 300 million people will have access to mobile phones within the next five years. In South Africa alone, the market penetration for mobile phones already stands at 100% of households. Nine out of every 10 phone lines on the continent are mobile (as opposed to landlines).

"There are many more mobile phone users in Africa than computer users," says Zaaiman. "Measure the above figures against the South African market penetration percentages for users of personal computers (6%), and those with broadband access (4%), of which only 0.5% use ADSL lines. It stands to reason that the primary opportunities for consumption of information are now through mobile phones, and that the way organisations communicate with their customers should be changing too."

mLabs to foster m-apps and socio-economic development

This is why the WB through infoDev – the Government of Finland and mobile phone manufacturer Nokia – is setting up seven mLabs in different parts of the developing world. Four of these mLabs are earmarked for Africa, two for South-East Asia and one for Eastern Europe. About $20 million has been earmarked for the programme.

In Africa, the East African mLab has been set up at the iHub in Nairobi, Kenya. The southern African mLab's hub is based at the Innovation Hub in Pretoria, South Africa, with 'spokes' (or regional offices) planned for different countries within the region. The first satellite has been identified in Cape Town, and its manager has already been recruited. The Southern African mLab is hosted by a consortium of the CSIR, The Innovation Hub, Innovation Lab and Ungana Afrika.

"The WB is all about socio-economic development, hence this investment," says Laurens Cloete, acting Executive Director of the CSIR Meraka Institute. "They believe that the people in the developing world are able to come up with innovative ways in which to tackle their own specific problems. The aim is to have a two-way flow of knowledge; by empowering them to become entrepreneurs either through

mobile applications

Laurens Cloete, acting Executive Director of the CSIR Meraka Institute, and Ben Zaaiman, manager of the CSIR-led mLab.

infoDev is a global development financing programme among international development agencies, coordinated and served by an expert secretariat housed in the Global ICT Department (GICT) of the World Bank.

developing m-apps themselves or by using m-apps developed for them, faster economical development can take place."

Nokia's role as a technical partner

Where infoDev acts as the implementer, Nokia acts as the technical partner. Cloete explains: "Ensuring that content and application developers have access to the latest mobile technologies and training programmes, Nokia gives 'in-kind' contributions such as bringing out experts to provide training or giving access to their handsets on which entrepreneurs can test their newly developed m-apps."

According to Zaaiman, Nokia is by far the world's dominant supplier of mobile phone handsets. "Yet these are predominantly feature phones, not smart phones," he says. "And in the developing world feature phones are the ones that are used overwhelmingly, even though the world is moving towards the use of smart phones."

At the AITEC East African ICT Summit, which was held in September 2010 in Nairobi, Jussi Hinkkanen, Nokia's Vice President for Government Affairs and Business Environment in the Middle East and Africa, said: "Mobile application and content will reach even the most disadvantaged population and provide new sources of wealth and innovation for entrepreneurs of the southern African region."

What the mLabs will do

While the CSIR-led mLab is still in an establishment phase, it has already attracted support from several industry players to assist with its continuation once the seed funding from infoDev and its Finnish partners has served its purpose.

The mLabs will provide:

- technical and business training and mentorship to potential m-apps entrepreneurs and developers;
- test laboratories;
- advocacy of mobile usage and applications; and
- structured channels in the marketplace between industry players (such as network providers and sms gateways).

"Apart from providing potential m-apps developers and innovators with all the support and facilities they could possibly need, we see ourselves as also being an implementation partner for NGOs and other public institutions that are particularly concerned with service delivery issues," says Zaaiman.

"Mobile applications and content will reach even the most disadvantaged population and provide new sources of wealth and innovation for entrepreneurs of the southern African region."

The mLabs are all expected to provide at least eight commercial applications within two years.

– Petro Lowies

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ICT in the service of emerging economies

The SAP Meraka Unit for Technology Development (UTD), a unique South African public-private partnership between government, a multinational in the field of collaborative business software and the CSIR Meraka Institute, occupies a singular research, development and innovation spot in South Africa's information and communications technology (ICT) landscape. The unit focuses on technologies for emerging economies, specifically Internet applications and services.

Fast facts on HCD@SAP Meraka UTD in 2011

12 full-time students

20 interns and students

First completed doctorate: Dr Marek Zielinski

SAP MERAKA UTD was the result of foreign direct investment by SAP in 2007, which was matched through investment by the Department of Science and Technology (DST) and the CSIR Meraka Institute.

The big picture

Danie Kok (Director: SAP Research IA&S and co-manager: SAP Meraka UTD) is clear on what the SAP Meraka UTD envisages, "We believe that we have a role to play by contributing to the building of local ICT research capacity. This is done by evolving the unit to a world-class research and development laboratory in the field of technologies for emerging economies." Technologies for emerging economies – explains Prof Jan Eloff (Research director for SAP Meraka UTD) – can be either new technologies or adapted technologies (taken from a first world context) and applied to business services for very small enterprises, for energy and for mobile health monitoring. "We aim to deliver tangible innovations," Eloff asserts.

He believes that the SAP Meraka UTD owes much of its success to its understanding of the challenges faced in emerging economies. Small and medium enterprises (SMEs) hold the key to influencing socio-economic conditions in a positive way. Achieving economic sustainability remains a vitally important factor for SMEs. Equally important is the imperative to provide access for aspiring entrepreneurs to the informal business sector.

Implicit in this understanding is the recognition of two important drivers: Co-innovation and business impact. "Our joint research undertakings must deliver value in terms of business," Eloff confirms. "Based on our understanding of this principle and of the challenges in emerging economies, and in line with our stakeholder expectations, we have adapted our research agenda."

Eloff sets these out: Research and development of new ICT solutions for emerging economies; measurement and validation of social and economic impact; and investment in methodologies, technologies and techniques for emerging economics.

This research agenda has in turn found expression in four directed research projects.

(Front) Danie Kok (Director: SAP Research IA&S and co-manager SAP Meraka UTD) and Jason Chuang (Middle) Prof Ernest Ngassm and Elmarie Venter (Back) Dr Marek Zielinski, Prof Jan Eloff (Research Director: SAP Meraka UTD) and Dr Danie Smit

Rustica

The first of these projects, Rustica, seeks to overcome barriers inhibiting rural entrepreneurship and the lack of access to mainstream or global supply chains and markets. This is done by introducing a large set of ICT solutions to the rural Living Lab community of Kgautswane in the Sekhukhune District Municipality in Limpopo. Kgautswane consists of 19 villages with a population of about 120 000, served by some 130 spaza shops. Rustica will introduce a system of a virtual buying co-operative (supported by the CSIR's network of Infopreneurs®), an increased product range and additional suppliers. The project will measure the effect of this intervention on the social and economic development in this community.

Overture

Very small enterprises (VSEs) of fewer than 20 people face severe challenges in terms of profitability, sustainability and the ultimate success of their businesses. To address the challenges of access to critical business services, the Overture project has devised a mobile business applications platform. Services are delivered via a mobile phone interacting with a collaborative multi-tenant back-end environment. The back-end is hosted by an intermediary such as a mobile telecommunications provider. Vodacom/Vodafone partnered in this project.

Isago

To broaden the scope of the mobile business solutions to VSEs, the project, Isago, aims to develop and evaluate a next generation platform. This will offer generic business services to support their economic sustainability. The innovation lies in the development of a prototype product catalogue for mobile phones as well as an algorithm for the intelligent retrieval of products. The latter takes into account factors such as the user's context, location, purchase history and preferences and limits the amount of data sent to the phone. A future development will be an algorithm for intelligent presentation of product items, taking the characteristics of individual mobile phones into account.

e-Energy

Rural and low-income households in South Africa are characterised by usage of a mix of energy sources (e.g. wood, electricity, gas and paraffin) for their daily heating, cooking and lighting needs. The e-Energy project aims to understand energy usage patterns in households in KwaMbonambi (northern KwaZulu-Natal), and will include quantifying usage of non-electrified energy sources. A mobile phone-based software console gathers information about energy usage in households. It also offers a tool for disseminating exemplary incentives to foster change in energy usage patterns of households.

Spaza shops are small convenience stores, operating out of people's homes or backyards and providing a vital service to people living in under-resourced communities.

SAP/Meraka UTD collaborates closely with the CSIR's Living Labs research efforts, led by Prof Marlien Herselman. The Living Labs approach ensures participation by all parties (including beneficiaries) in all phases of the project.

Looking ahead

Kok and Eloff are keen for SAP Meraka UTD to continue to develop innovative applications for emerging and fast-growing markets, as well as approaches and technologies for delivering innovative applications (cloud, mobile, on demand and on device).

"As a local research unit, the SAP Meraka UTD contributions are unique and valued by SAP," Kok concludes. "We believe that we can continue to deliver novel solutions for emerging markets, which could be useful in the developed world." – Biffy van Rooyen

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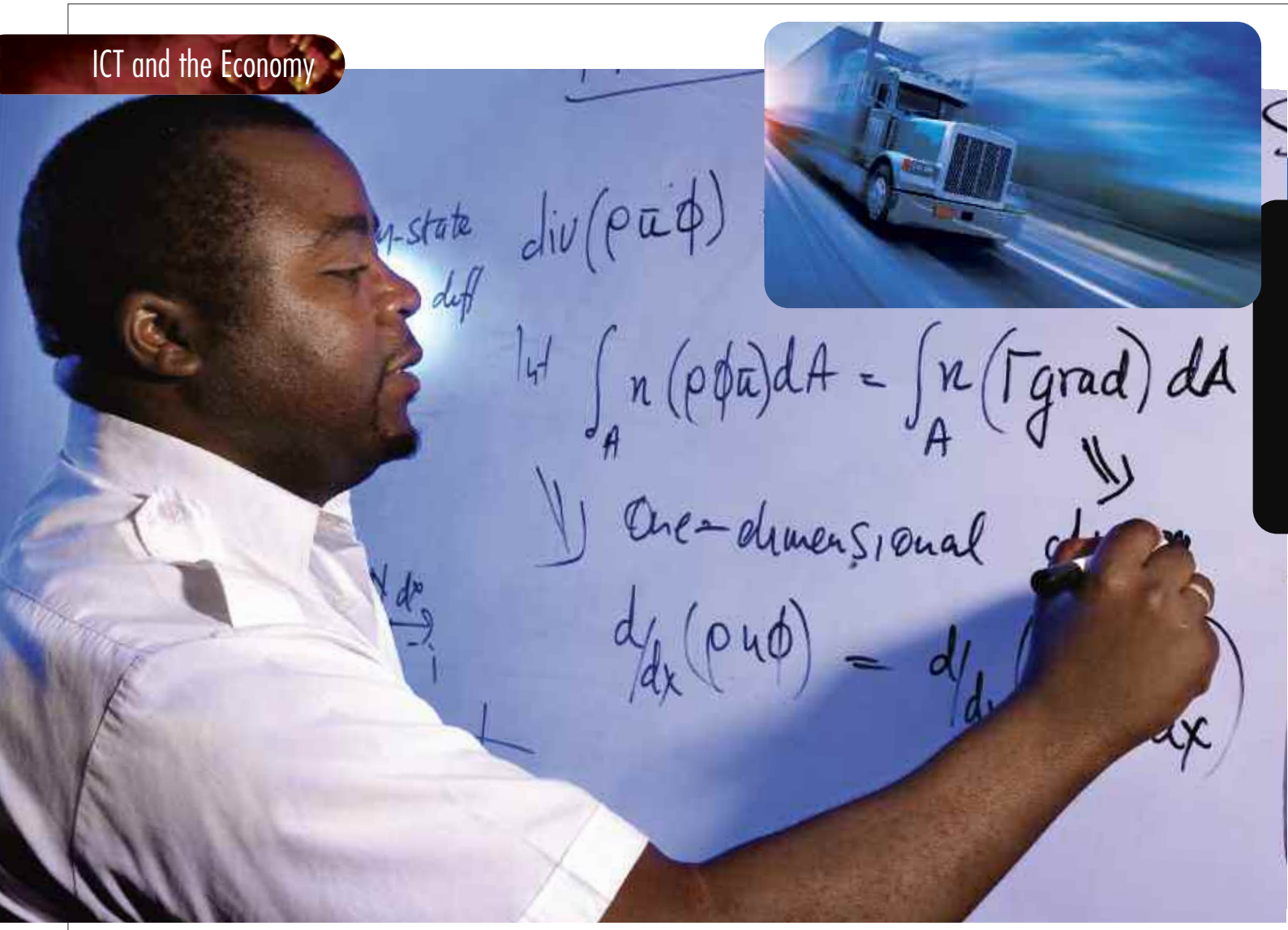


Dr Njabulo Siyakatshana

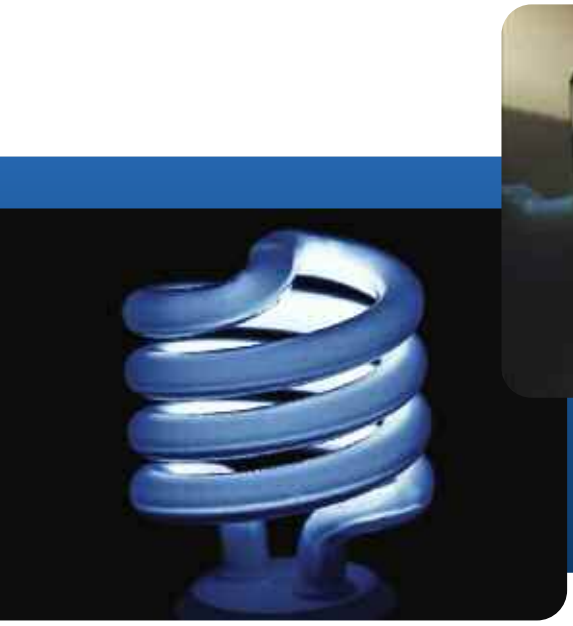
Novel web-based calculator to estimate emissions and general carbon footprint

The CSIR has designed a web-based calculator to quantify carbon emissions.

THE INPUT DATA to the web-based calculator needed are fuel consumption; electricity cost or consumption; employee air travel; airborne, rail cargo weights and distances; and inventory of refrigerants. The calculator will help the enterprise estimate emissions from operations and take necessary remedial action if required. This methodology for calculating emissions emanates from the usage of transportation fleet and a carbon footprint from enterprise activities in general. The two main greenhouse gases deemed to cause global warming have been identified as CO_2 and CH_4.

Other greenhouse gases include N_2O, hydrofluorocarbons, perfluorocarbons and SF_6, although these occur to a lesser extent than the former two.

Dr Njabulo Siyakatshana, project leader, says that the aim of this novel web-based emissions calcu-



lator is for the client to be able to account for its emissions. "The client wants to have a database where it can quantify its carbon emissions," he says. "The objective is to encourage emissions accountability in state-owned enterprises."

He adds that the aim of the client is to look at its strategy and see where it can reduce greenhouse gas emissions and carbon footprint.

Siyakatshana and his team did not develop any new technology. This application, however, is unique to the client's needs. "The client wanted to quantify the emissions released from its electricity consumption, vehicle fleet usage and other forms of freight transportation such as airborne, rail and road," he says. "We also included a balance of refrigerants to quantify emissions resulting from air conditioning."

Tools used

This, notes Siyakatshana, was a desktop study; no field work was carried out. He says that his team collected data from the United States Environmental Protection Agency, the Society for Automotive Engineering and the IPPC because "these organisations already have comprehensive and openly-available databases on emission factors".

"With this kind of data, we could reach our objectives by developing this user-friendly application," he says.

Siyakatshana adds, "Although this application is specifically designed for the client, it is customisable for other sectors because the methodology would be similar."

Impact

"This will have an environmental impact on both the public and the private sectors," he says, adding that neither of these sectors has developed methodologies to accurately quantify their carbon emissions. "There will come a time where South Africa – as a signatory of the Kyoto Protocol – will have to account for its carbon emissions."

Meanwhile, emissions from the enterprise activity in consideration were categorised as follows:

Vehicular emissions

The main emissions from road transport are mainly carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC), methane (CH_4) and particulate matter (PM). These are in addition to heavy metals release, mainly lead (Pb) and sulphur oxides (SO_x) and a host of other unregulated emissions such as poly aromatic hydrocarbons and persistent organic pollutants. Vehicles considered in the study range from passenger cars, light duty, heavy duty, motorcycles and forklifts. Input data for these calculations are petrol or diesel consumption in litres.

Electricity-based emissions

All electricity-based operations release carbon dioxide and other greenhouse gases during their lifecycle. These emissions can be direct, that is, arising from firing the power plant, or indirect, that is, arising from other phases such as mining and transportation of the fuel during its life cycle. The main greenhouse gases tabulated are CO_2, CH_4, and N_2O.

Air travel emissions and airborne cargo

The calculation of emissions from flights is an evolving and complicated area, and different calculators available result in different values. One factor that has a large influence on the calculation is the Radiative Forcing Index (RFI). This incorporates the global warming effects planes have because of the altitude at which they emit. An average value tabulated by the Inter-Governmental Panel on Climate Change (IPCC) was used.

Rail freight

These are normally tabulated as CO_2 equivalents. The European standard of CO_2 25 g/ton-km are actually on a downward trend from a high of CO_2 35 g/ton-km in 1990. However, these figures are more significant for enterprises operating chiefly on rail cargo transport.

Refrigerants

Air-conditioning equipment is a source of potent greenhouse gases in the form of chloro-fluoro carbons. They have global warming potentials thousands of times greater than CO_2 although they are not released in comparable quantities. These are released chiefly by leakage during charging, operation or servicing. An up-to-date inventory and mass balance help track the leakages and quantify the emissions. – **Mzimasi Gcukumana**

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Visit: http://www.csir.co.za/publications.html for previous issues of the ScienceScope

Digital Doorway™ – Opening the doors to ICTs

THE DIGITAL DOORWAY (DD) initiative was introduced five years ago by the Department of Science and Technology (DST) and the CSIR as a way to improve computer literacy and access to information.

Underpinning the project is the concept of people's inherent ability to teach themselves and gain information with minimal external intervention. For this to happen, computers must be easily accessible to potential learners (children and adults) in an environment conducive to experimentation.

The robust DD can be placed where they are most accessible to users. There are currently 220 systems in South Africa.

The CSIR is also collaborating with Monash University of Melbourne, Australia, and UNICEF Pacific to reach remote communities in these areas and help overcome the digital divide.

The DD comes in different configurations: single seater; three seater; for people with disabilities; and the container Digital Doorway™.

The latter is run on solar energy and is rugged enough to be placed in exposed locations. – **Bonang Tselane**

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"Chatting our way to better maths"

DR MATH is a mobile tutoring service which allows mathematics learners to use the MXit mobile instant messaging service on their cell phones to access tutors who provide real-time support and assistance with mathematics homework and revision. This project was initiated in 2007; there have been 17 000 registered users to date.

When using Dr Math, learners are able to have a one-to-one 'conversation' with a tutor who supports them in solving mathematical queries (e.g. maths homework) in real-time. The service can be likened to a text-based call centre, where individual learners are assigned to tutors, based on tutor availability.

Tutors are people who have a strong mathematical background and who are trained to use Dr Math. They are required to understand how to use the medium and conform to a strict code of conduct. The tutors are managed in a similar way to call centre agents and are available Sundays to Thursdays between 14:00 and 20:00. There are currently 110 volunteers from around the country – most are engineering students from the University of Pretoria.

The CSIR has, however, over the past six months developed a generic set of tools that enables anyone to set up a similar service to Dr Math. The toolset is known as 'C3TO' (Chat Call Centre Tutor Online), which currently uses the MXit platform as a channel, but can utilise other platforms that support Google Talk.

Commercialisation

The CSIR has a long-standing relationship with the Department of Basic Education, a major role player in the successful implementation of the Dr Math initiative.

The CSIR is also working on licensing Dr Math to an independent organisation that will be capable of offering the service nationally (initially and thereafter internationally) and grow the initiative to achieve impact and deliver on stakeholders' expectations. – **Bonang Tselane**

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Making ICTs available to persons with disabilities

The National Accessibility Programme (NAP) was initiated in 2004 as a five-year research programme to address the marginalisation of persons with disabilities from the mainstream society and economy. This project also sets out to ensure that persons with disabilities participate and are included at all levels of society through the use of information and communications technologies (ICT).

Key assets in the NAP suite include:

- An accessible web source code that enables assistive technologies such as screen readers
- A website/portal using the source code and set up for persons with disabilities
- Technical developments such as GNApp (an open source augmentative and alternative communication framework) and the Notetaker (a computer for the blind).

NAP looks to service the new Ministry for Women, Youth, Children and Persons with Disabilities, as well as other government departments.

In order for NAP to achieve maximum potential and impact, it must be transferred to an appropriate implementation vehicle that will be responsible for operationalising an independent and sustainable NAP and its associated interventions nationally and into Africa.– **Bonang Tselane**

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Seeing the world through different eyes

The dream to have access to electronic documents and information and be part of the global move towards accessing the Internet through modern communications and computing tools, has now become reality and will soon be available to the average visually-impaired consumer.

This is thanks to the work of the CSIR in the development of the Notetaker. The Notetaker – a 'computer for the Blind' – is an indigenous technology focusing on low cost, affordability and value benefits. It is aimed at improving accessibility by mainstreaming persons with disabilities into society through the use of information and communications technology (ICT). This technology was designed and developed by senior technologist, Willem van der Walt, who is blind.

In 2009, the World Health Organization (WHO) estimated that there were about 314 million people worldwide living with visual impairment. Of those, 45 million were blind, 90% of whom were living in low-income countries. This meant that a lot of blind people are in disadvantaged situations due to a lack in resources.

The 'computer for the Blind' is a first of its kind in South Africa because it is a customised solution that provides support for multiple indigenous languages, currently including English, Afrikaans and IsiZulu. Notetaker also has the potential to make immediate impact in the education and employment sectors.

The research and development stage of this technology is now complete and it has reached the commercialisation stage. The CSIR is currently working with Micro Link SA, an implementation partner to take the Notetaker to the market. Micro Link PC specialises in the supply of computer hardware, software and other specialised equipment not only to support people with disabilities, but also to enable professionals to maximise their output within their workplace.

In addition to Micro Link, the CSIR is exploring other partnerships for product development and testing as well as for marketing, support and maintenance of the notetaker.
– **Bonang Tselane**

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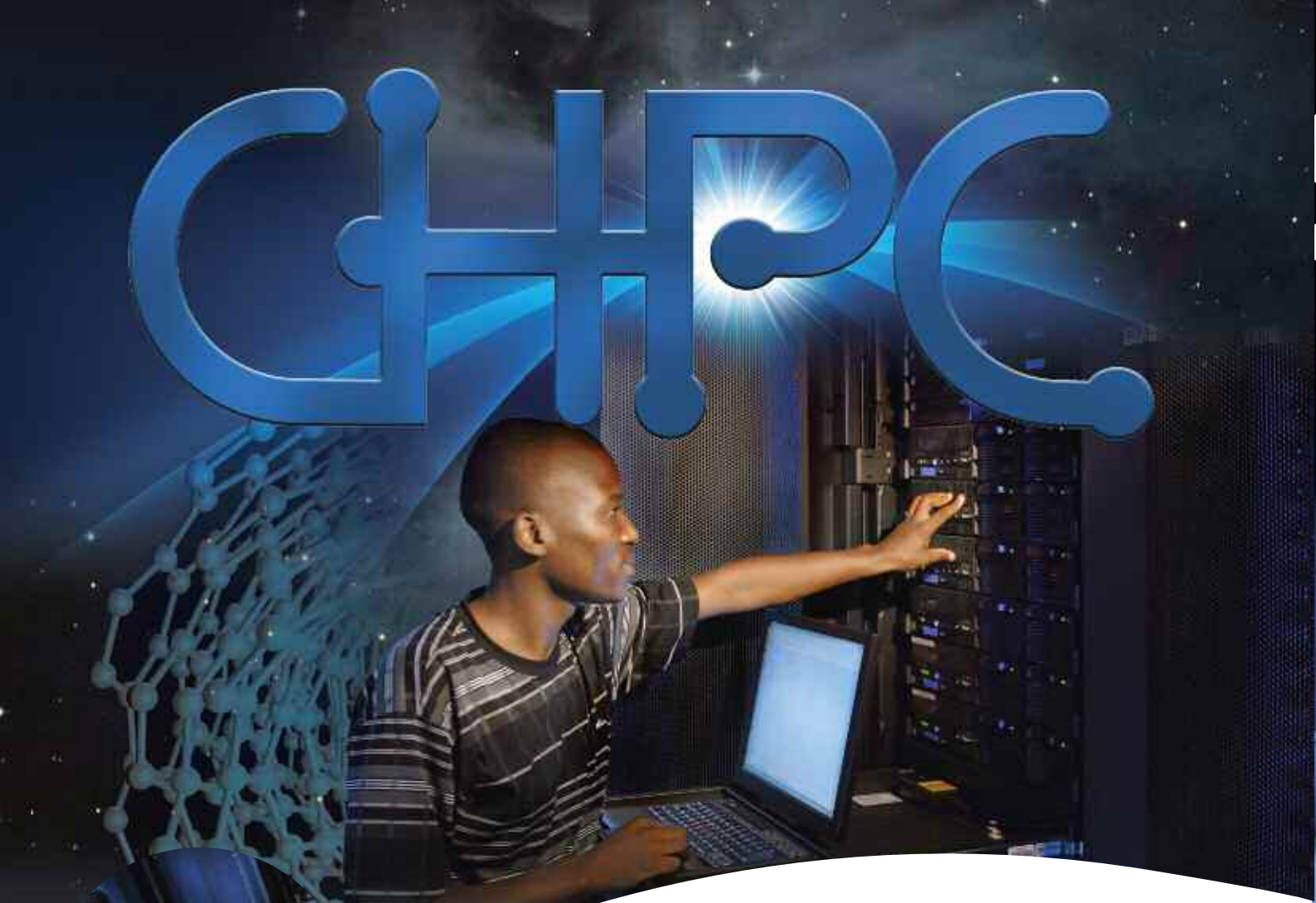

Computational Platforms

IBM e1350 Cluster – 640 CPUs at 2.5 teraflops measured performance.
IBM Blue Gene-P – 11.5 teraflops measured performance.
IBM P690 SMP – 166 gigaflops peak performance.

Sun SPARC Enterprise M9000 server with 64 SPARC64 VII quad-core processors, and a cluster of four Sun Blade 6048 Modular Systems.
The cluster houses a total of 192 nodes based on the next-generation Intel Xeon E5450 processor (Nehalem) – 27 teraflops total peak performance.

Storage solution based on ten AMD Opteron-powered Sun Fire X4540 Open Storage servers, providing 480 terabytes of data with the Lustre parallel file system for extreme I/O performance and reliability.

Range of clusters with other computational components:
GPGPU – General Purpose computing on Graphics Processing Units
FPGA – Field-Programmable Gate Arrays.

CHPC
CENTRE FOR HIGH PERFORMANCE COMPUTING

Research and Education

The CHPC is part of South Africa's national cyberinfrastructure intervention: Supported by the Department of Science and Technology (DST) and hosted by the Council for Scientific and Industrial Research (CSIR). Other complementary national cyberinfrastructure includes: South African National Research Network (SANReN) – provision of highspeed, highbandwidth connectivity, and Very Large Data Sets (VLDS) – effective curation of a variety of notably large data sets.

Advancement of scientific boundaries by enabling world-class research through promoting and facilitating the use of computational technologies and techniques amongst researchers.

Fostering of innovation through effective partnership for training a new generation of skilled researchers in areas underpinned by high performance computing and data curation, particularly those of strategic national and continental importance. Promoting private public partnership and the utilisation of the high performance computing by the commercial sector.

The CHPC invites all researchers to take advantage of its cyberinfrastructure.

The CHPC seeks joint research and HCD initiatives with its stakeholders.

For more information **www.chpc.ac.za**

Loretta Steyn Graphic Design Studio