



# MORE THAN JUST A COMPUTING CENTRE



***Besides serving as the hub for computational facilities at the Indian Institute of Science (IISc), the Supercomputer Education and Research Centre (SERC) also imparts education and carries out its own research***

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“Even though the facilities we manage are significantly large, it should not undermine our emphasis on research and education,” says R Govindarajan, the Chair of SERC, underlining the dual role played by this unique centre in India. SERC, renamed in 1990, began as the Computer Centre back in 1970. Today, besides providing state-of-the-art computing facilities to faculty members and students in the Institute, the Centre also carries out its own research and offers Master’s and PhD programmes.

## **Metamorphosis**

“It was the vision of Prof. V Rajaraman and Prof. N Balakrishnan that education and research should be integral to SERC,” Govindarajan adds. Rajaraman, a pioneer of computing in India, was invited in the early 1980s from IIT Kanpur to head the Computer Centre at IISc. He steered the transformation of this

Centre into its current avatar along with Balakrishnan. Under the chairmanship of Balakrishnan, who succeeded Rajaraman, the Centre rose to the level of a leading supercomputing facility and was dedicated to the nation.

Balakrishnan says that the expansion of the Computer Centre and its transformation into an academic department received whole-hearted support and encouragement from S Ramaseshan, the Director of IISc from 1981 to 1984, and then from CNR Rao, who headed the Institute from 1984 to 1994.

## **Blessing in Disguise**

Among the first initiatives that Rajaraman and his team undertook was to acquire a supercomputer. After visits to several high-performance computing centres in the UK and US, a specially



appointed committee that included Rajaraman and Balakrishnan decided on a Cray Y-MP. However, export restrictions imposed by the US government—still fighting the Cold War—prevented the transfer of this machine.



V Rajaraman, the founding Chair of SERC

Reflecting on this inauspicious start in its efforts to reinvent the Computer Centre, both Rajaraman and Balakrishnan believe that this was a “blessing in disguise.” With the same money, the Centre was now able to put in place a set of distributed computing systems. This included a high-end mainframe computer from IBM, a large number of workstations, graphics machines and several mini-computers. And for the first time in the country, a campus-wide fibre optic network was also established. Govindarajan believes that the functionally distributed supercomputing setup, introduced at that time, helped the Centre retain its edge in supercomputing, despite the fast obsolescence of computer systems.

### Facilities

Over the years, SERC has had several supercomputers. A supercomputer is any machine that has a set of processors that are connected together, says Govindarajan. But he is quick to add that what is considered a supercomputer today will not have the same tag a few years down the

line. “I always define them as the few fastest systems in operation today,” he explains.

In the last few decades, as parallel processing speeds have grown exponentially following Moore’s predictions, SERC’s computing facilities too have been constantly upgraded. Its latest acquisition is a Cray XC40, India’s fastest supercomputer (see box). “We want to ensure that the best technology is available to our users,” says Govindarajan. SERC also procures and manages licences for software—both generic and specialized—for the Institute’s researchers.

The role of SERC as a central computational facility—used by researchers cutting across various disciplines—is articulated by J Lakshmi, a principal research scientist at the Centre. “Large-scale systems are complex and expensive. Individual departments cannot manage and maintain these systems. In addition to skilled system administrators, you also need a good, reliable infrastructure that includes uninterrupted power supply with backup and cooling. So it makes sense to have a central facility,” she says.

### Education

Besides offering PhD and research-based Master’s programmes, SERC also has an M.Tech programme in Computational Science. Govindarajan is keen to emphasize that this M.Tech is different from traditional computer science programmes. “The programme focuses on helping students—who come from different disciplines in science and



R Govindarajan



engineering—use computers effectively to solve large problems in their fields,” he clarifies. Besides courses in programming, numerical methods etc., students also take courses in their fields of specialization. The two-year programme culminates with a domain-specific dissertation project which is computational in nature.

### Research

Sathish Vadhiyar, an associate professor at SERC, works in high performance computing systems. His research interests include building middleware and runtime systems. Middleware is the interface between the user and the system. The supercomputers at SERC have multiple users who submit their tasks for execution; this leads to job queues. Vadhiyar builds middleware that predicts queue waiting times and also advises users on the most optimal strategy to use to reduce the total response time (the sum of queue waiting time and execution time). His other area of research in runtime systems seeks to speed up specific scientific applications—for example, climate modelling—using state-of-the-art accelerators.

Vadhiyar is among the more than 20 faculty members at SERC who carry out research in two broad areas of computing: *Computational Science* and *Computer Systems*. “In the area of Computational Science, which deals with computational methods and their applications to other areas of research, we have faculty members who work on fields as diverse as medical image processing, computational photonics, and bioinformatics. In Computer Systems, we have research that focuses on computer architecture, high-performance computing systems, cloud visualization and the like. We also have faculty who work on database systems, information systems and video analytics,” says Govindarajan, speaking about the breadth of research carried out by SERC’s faculty members.

Among SERC’s many research projects is the Digital Library of India (DLI)—one of Balakrishnan’s initiatives. It is a digital collection of books, many of them rare, from various libraries in India. DLI, hosted at SERC,

aims to archive all significant works—in different fields of human endeavor including science and literature—and make them freely available on the internet. “About 144,000 pages are downloaded every day,” says a delighted Balakrishnan, highlighting the success of the initiative.



**N Balakrishnan**

The research efforts of Jayant Haritsa, a professor at SERC, has also drawn attention—it has resulted in copyrighted software, widely downloaded and used in both academia and research.

### National Supercomputing Mission

The Government of India only recently approved the National Supercomputing Mission (NSM). The Mission, said to cost Rs 4,500 crores, will establish a few dozen supercomputing systems in academic and R&D institutions across the country. IISc and the Centre for Development of Advanced Computing (C-DAC) will be the two major implementing agencies for this Mission that seeks to take supercomputing to different parts of India.

Besides being a nodal agency for this project, IISc has played a crucial role in conceiving NSM. Balakrishnan, who has piloted the Mission since its inception and will be leading its activities nation-wide, says that IISc was approached by the Government to take a lead in NSM because of its many years of experience in supercomputing and networking.



## सहास्रतः: India's First Petascale System



Some stars die dramatically in massive explosions called supernovae. Prateek Sharma, an astrophysicist from the Department of Physics, is interested in how multiple supernovae going off in a small volume—sometimes almost simultaneously—affects the interstellar medium around it (and how the medium in turn influences the birth of new stars). To understand this phenomenon, he runs complex simulations by exploding virtual stars in a patch of interstellar medium on IISc's newest supercomputer—a Cray XC40 christened *Sahasrat*.

"It is no ordinary machine," says Balakrishnan about *Sahasrat*, India's fastest supercomputer. The speed of a supercomputer is measured as the number of floating-point operations it performs per second (or just FLOPS). *Sahasrat* has a peak performance of 1,320 TeraFLOPS ( $1,320 \times 10^{12}$  FLOPS)—hence the name *Sahasrat*—and a sustained performance of over 900 TeraFLOPS.

Not surprisingly, *Sahasrat*'s architecture is complex and its design, intricate. Its basic unit is a replaceable blade; each blade is made up of four nodes; each node in turn has 24 cores; 16 such blades are assembled on a chassis; three chassis units comprise a rack, of which there are 8. In all, this workhorse has

33,000 cores. "Each node can have its own software and operating system. In that sense, each node is an independent computing system," Lakshmi explains.

*Sahasrat* has Intel's Haswell processors at its heart, delivering its computing power. Another crucial factor that influences its performance is how the different nodes in the machine "talk" to each other—called network topology. *Sahasrat* has a topology named Dragonfly with an Aries Network-on-Chip (NoC). But the hardware alone does not determine a supercomputer's performance; it also needs the appropriate software environment to exploit its architecture. *Sahasrat* comes with a specialized, complete Cray software stack. With one eye on the future, SERC has also ensured that *Sahasrat* has two accelerator-based cluster systems—one having graphics processing units and the other having Intel's Many Integrated Cores (MIC).

Though it was installed only a few months ago, *Sahasrat* has a utilization of more than 80%. According to Govindarajan, at least three research groups on campus have been able to utilize the capabilities of the machine as a large High Performance Computing (HPC) system. "It has been very well received," an understated Lakshmi adds with a smile.