



ANNUAL REPORT

2006-2007

Governing Council

Shri Dayanidhi Maran

Chairman, Governing Council C-DAC and
Hon'ble Minister of Communications & Information Technology

Shri Jainder Singh

Vice Chairman, Governing Council C-DAC and
Secretary, Department of Information Technology,
Ministry of Communications & Information Technology

Dr. T. Ramasami

Member, Governing Council C-DAC and
Secretary, Dept. of Science & Technology,

Shri M. M. Nambiar

Member, Governing Council C-DAC and
Additional Secretary, Department of Information Technology
Ministry of Communications and Information Technology

Dr. A. K. Chakravarti

Member, Governing Council C-DAC and
Advisor and Group Coordinator (R&D in IT),
Department of Information Technology,
Ministry of Communications and Information Technology

Shri E. K. Bharat Bhushan

Member, Governing Council C-DAC and
Joint Secretary & Financial Advisor,
Department of Information Technology,
Ministry of Communications and Information Technology

Dr. F. C. Kohli

Member, Governing Council C-DAC and
Ex Dy. Chairman, Tata Consultancy Services and
Member Executive Committee, TCS

Prof. N. Balakrishnan

Member, Governing Council C-DAC and
Associate Director,
Indian Institute of Science

Shri S. Ramakrishnan

Member, Governing Council C-DAC and
Director General, C-DAC

Dr. U. R. Poharkar

Secretary, Governing Council C-DAC, and
Registrar, C-DAC

Shri D. S. Mathur, Vice Chairman, GC & Secretary, DIT upto 16.07.2006

Professor V. S. Ramamurthy, Member, GC & Secretary, DST upto 30.04.2006

Dr. R. A. Mashelkar, Member, GC & DG, CSIR and Secretary, DSIR upto 31.12.2006.

Shri Ajeer Vidya, Member, GC & JS&FA, DIT upto 31.10.2006

Shri C. Balakrishnan, Member, GC & AS&FA, DIT from 01.11.2006 to 31.01.2007



Contents

Overview

01

Technical Activities

03

Resources, Facilitating Services and Initiatives

90

Financials

97

Overview

Centre for Development of Advanced Computing (C-DAC) is the premier R&D organization of the Department of Information Technology (DIT), Ministry of Communications and Information Technology (MCIT) for carrying out R&D in Information Technology, Electronics, and Associated areas. During the year 2006-07, C-DAC further consolidated its core R&D areas, which are as follows:

- High Performance Computing and Grid Computing
- Multilingual Computing and Allied Areas
- Software Technology (Including OSS/ Linux)
- Professional Electronics (Including VLSI and Embedded Systems)
- Cyber Security and Cyber Forensics
- Health Informatics

An overview of significant activities carried out by C-DAC in these areas during the year 2006-07 is discussed below. An overview of the activities carried out in other areas of operation such as Education and Training, Consultancy Services, and Facilitation Services are also included.

High Performance Computing

Good progress was made in finalizing the architecture of Next Generation PARAM System and evaluation of off-the-shelf components including Compute Nodes, Primary and Secondary Networks, High Performance Storage, and Software Stack. Significant progress was also made in the design and development of indigenous components including PARAMNet-III System Area Network, Reconfigurable Computing System (RCS) based accelerator card, and system software and tools.

The national *Grid Computing* project progressed smoothly resulting in practical implementation of the prototype grid “GARUDA”, enabling the partners and affiliates across the nation to appreciate the experience of grid technology. In addition to aggregation of compute, storage, and other resources across various C-DAC centres and partner sites, several tools and technologies were also developed, deployed, and tested on the prototype grid. These included Garuda Access Portal, Garuda Program Development Environment, and Garuda Monitoring and Management software. Several workshops and Garuda partners’ meet were organized to disseminate information about Garuda and its usage methodologies. C-DAC also started “EU India Grid” project, joining European and Indian Grids for e-Science network community.

Multilingual Computing and Allied Areas

Efforts continued towards design and development of Localization Frameworks, Productivity Enhancement Tools and Technologies, Machine Translation Systems, Character Recognition Tools and Technologies, Web Based Tools and Technologies, Language Learning Tools Technologies, Indian Language Fonts, and Indian Language Digital Library. Several Indian language CDs were also designed and released as part of the National Rollout initiative.

Software Technology

Several Software Engineering tools were developed to ease the task of software development and maintenance. Additionally, several software solutions were developed for various vertical sectors including those for e-Learning, Land Management and Area Planning, e-Governance, Virtual Museum, etc. Several initiatives were also taken for Open Source Software development. An Indian version of Linux named “BOSS Linux” was developed as part of this initiative.

Professional Electronics

Several tools and technologies were developed and deployed for Generation, Distribution and Efficient Utilization of Power, Process Control, Traffic Control, and Vehicle Tracking. Several tools and technologies based on RFID and Acoustic and Magnetic Sensors were also developed. Efforts continued towards further perfection of Electronic Nose, Electronic Tongue, and Electronic Vision systems for their increased use in quality testing of agricultural products. Systems based on TETRA technology were further enhanced for their larger use. Several other technologies and products were developed including Digital Programmable Hearing Aid, Software Defined Radio, Compact IP Telephone, IP Set Top Box, Medical Investigation Camera for Endoscopy, Biometric Identification System, GPS Based Station Name Displaying System, etc. Several specialized research laboratories were also setup to enable high-end R&D work in these areas.

Significant efforts in the area of *Cyber Security* included development and commercialization of Cyber Forensics tools and imparting of Cyber Crime Awareness and Prevention Programs for law enforcement agencies. Other efforts in this area during the year included development of Intrusion Detection and Response Systems, End System Security Solutions, Cryptanalysis Techniques, and Information Security Awareness Programs.

Health Informatics

C-DAC continued with its efforts to deploy its Telemedicine Solutions in several states in India. A telemedicine solution was also deployed in Ethiopia. C-DAC continued to work towards enriching the features of its Health Management Information Systems (HMIS) and deployed the same in several additional hospitals and healthcare centers. It also continued its efforts towards computerization of healthcare centres and development of other tools and technologies for better healthcare such as Ayusoft, Decision Support System for “Nadi Pariksha”, and Onconet India project proposal.

C-DAC is developing a coordination and context-aware middleware for *Ubiquitous Computing* using Ubiquitous Semantic Space and Ontology based Context Aware Environment for ubiquitous computing.

C-DAC continued its foray in *Education and Training* through its plethora of both formal and non-formal training programs with the objective of sharing the knowledge generated in its R&D activities with students and the industry.

In addition to its efforts towards Technology Development and Education and Training, C-DAC continued to put efforts towards improvement of its manpower and other resources, facilitation services, and consultancy services.

Technical Activities

High Performance Computing and Grid Computing

Next Generation PARAM

As its next milestone delivery in HPC, C-DAC is working towards the delivery of Next Generation PARAM system for the last few years. The targeted system will have sustained computing power of more than 10 Tera Flop and is scheduled to be commissioned in the third quarter of 2007. Significant progress was made during the year in this activity as described below.

System Architecture

The architecture of the system was finalized based on the requirements of some key scientific and engineering applications. Later, significant progress was made towards evaluation and selection of the off-the-shelf components including Compute Nodes, Primary and Secondary Networks, High Performance Storage, and Software Stack. Analysis of key aspects of memory performance of multi-core processors that are being seriously considered as compute engines for the new PARAM system were also carried out.

PARAMNet-III System Area Network (SAN)

PARAMNet forms a major indigenous component of all our PARAM systems. PARAMNet-III is the next generation PARAMNet that will be used as a SAN for building the Next Generation PARAM system. Significant progress was made during the year towards the design and development of this important indigenous component of the Next Generation PARAM system.

PARAMNet-III supports speeds of 10 Gbps full duplex and has standard software interfaces including User Level Direct Access Protocol Library (UDAPL). It is designed to offer the best price performance ratio for interconnecting High Performance Clusters of Workstations, Servers or Personal Computers. The message latency expected is of the order of 5 μ sec. The basic switch is a 48 port switch based on back plane rack design approach designed around Xilinx Virtex4 devices and Fulcrum 2232 chip. It will have PCIe (Express) host interface and multiple 10 Gbps link interfaces. Industrial design and packaging of this rack based 48 port switch is a major design effort covering ergonomics, aesthetics, thermal, and EMI/ EMC design.

Status of developmental activities of various subsystems of PARAMNet-III during the period under consideration are as under:

- **Switch.** Design of PCBs for Backplane and Line Card is over. Purchase Orders have been released. All other components have been procured. Industrial Design and Packaging of Switch Chassis is completed. One prototype is fabricated with dummy PCBs and evaluated for thermal design and electrical loading point of view and the results are quite satisfactory. Assembly, integration and testing of actual switch prototype will start after PCBs have arrived.
- **Network Interface Card (NIC).** Integration and testing of various modules of C-DAC's Communication Co-processor (CCP) called GEMINI is in progress. Design Layout of NIC PCB is in progress.
- **Firmware.** Design of firmware for UDAPL and OPENIB Standards is under progress.

Reconfigurable Computing System (RCS)

RCS is yet another indigenously designed component for the Next Generation PARAM system. It is an accelerator card for accelerating performance of applications run on PARAM systems. During the year, the activities in this area were focused towards RCS platform for bioinformatics research (Xpress Search) as mentioned below.

Significant progress has been made during the year under consideration in deployment of RCS Card for Smith Waterman Algorithm. The sizes of Query and Database now supported have enlarged significantly for meeting most of the requirements of Research Labs and Industries. This technology was demonstrated and poster presentation was made at International Conference on Bioinformatics (InCOB06) held at New Delhi. Currently discussions are on with Ocimum Biosolutions, Hyderabad for offering RCS for Smith Waterman along with their Bioinformatic Software Products for Indian as well as the International market.

System Software and Tools

Increased (availability and) usage of higher precision systems prompted the development of 64-bit system software tools.

- C-DAC successfully built 64-bit version of C-DAC Message Passing Interface (C-MPI) to work with the PARAMNet-II and Gigabit Ethernet interconnects on AIX5.1.
- It is also working on studying the Parallel File System scalability and portability issues to provide high performance cluster based storage system.

In the compiler domain, C-DAC executed an order to conduct feasibility study of Ada Cross Compiler development from Aeronautical Development Agency (ADA).

Grid Computing

GARUDA – The National Grid Computing Project, being pursued with great enthusiasm, made landmark achievements during this year. The pen-and-paper designs were practically implemented to provide a prototype grid so that the Partners/ Affiliates can appreciate the experience of Grid Technology. Acceptance tests were carried out at partner sites for the high-speed network connecting the 45 locations.

In addition to bringing together compute, storage and other resources across centers, C-DAC has developed several enabling tools for seamless usage of GARUDA; these include GARUDA Portal, Program Development Environment and GARUDA monitoring and management software. Workshops and GARUDA Partners' meet were organized to disseminate information about GARUDA to strengthen collaborations. Applications were demonstrated on GARUDA to provide insight into the scalability issues and importance of Grid Computing. Some of the applications tried out on GARUDA include –

- The Disaster Management (monitoring) using terrestrial and satellite grid, in collaboration with Space Application Center – ISRO;
- Bioinformatics applications for searching genome databases and protein folding and
- Storage Disaster Recovery using Storage Resource Broker.

The GARUDA Task Forces (for Communication Fabric, Deployment and Training, Technology Development and Applications) played a major role in coordinating and putting together this vast project.

As a part of the GARUDA project, the high-speed communication network was established at 45 locations with the help of ERNET and Sify. Subsequently, the GARUDA middleware components are being deployed in coordination with the grid administrators' team from Bangalore, Pune, Chennai and Hyderabad. To ease the deployment step, initial training of GARUDA software installation was organized in Bangalore in April 2006 where all the grid administrators from the C-DAC centres attended the programme. C-DAC has also set up a Request Trackers System to aid the help desk operation for both internal users and GARUDA users. In this connection, a 4x4 video wall was established to monitor and manage the major/ critical components of GARUDA throughout the country.

More details on various components of GARUDA are given below along with other associated initiatives.

GARUDA Communication Fabric

The GARUDA network is a Layer2/ 3 MPLS Virtual Private Network (VPN). 45 earmarked research/ academic institutions across 17 cities in the country were interconnected During this year and the User Acceptance Test (UAT) completed for all. Separate test was conducted to check the backbone bandwidth simultaneously across all the sites.

GARUDA Resources

In this collaborative grid project, various resources such as high performance computing systems and satellite based communication systems have been committed by different centres of C-DAC and GARUDA partners. More than 300 CPUs have been committed to GARUDA. It may be noted that the resources being diverse in nature, one of the major challenges of GARUDA is to deploy appropriate tools and middleware to enable applications to run seamlessly across the grid.

GARUDA Monitoring and Management

A dedicated Grid monitoring and management centre at C-DAC, Bangalore with state-of-the-art display walls helps in managing and monitoring all the components in the Grid. CDAC has developed the tool *Paryavekshanam* to monitor the grid GARUDA. Its name is coined from Sanskrit language, meaning, "to monitor". This is a very essential utility to detect, record, and report any faults and service degradations in a very large and complex Grid Computing facility. It facilitates speedy rectification and ensures that the grid operates in an optimal manner. The *Paryavekshanam* tool operates with a 2800 X 2100 resolution on the display wall in the GMMC at C-DAC Bangalore. It also runs on the desktops with normal 800 X 600 resolution.

GARUDA Middleware and Technology Components

Several enabling tools and technologies including grid middleware, secure access methods and program development environments have been deployed on GARUDA.

GARUDA Grid Debugger

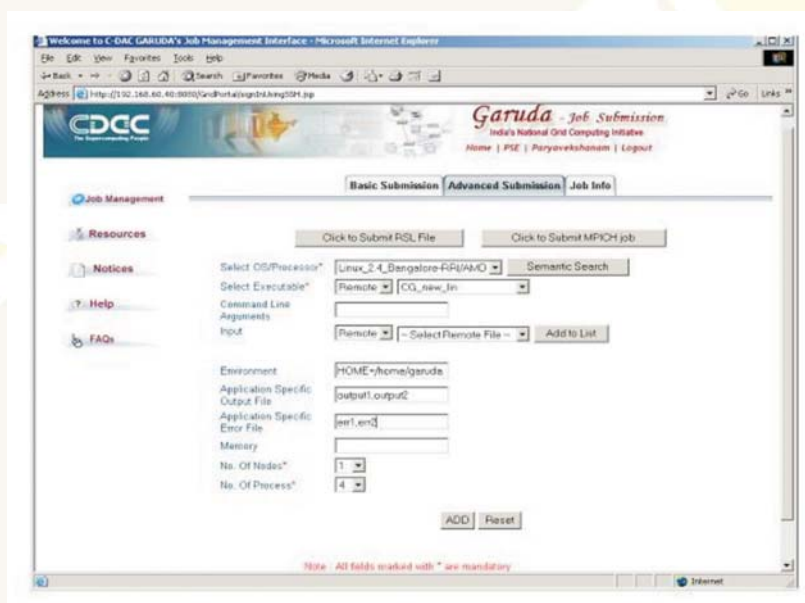
'Gridhra' is a web based debugger and visualization tool for parallel applications on the Grid. Designed specifically to meet the scalability and heterogeneity concerns in a grid, this tool offers a unified interface for performing both correctness and performance debugging of grid-enabled parallel applications. Deployed as a web tool, 'Gridhra' frees the user from the hassles of remote debugging and performance visualization of such applications.

Currently 'Gridhra' has been successfully tested and deployed on the Garuda test-bed comprising Linux and AIX machines distributed over Bangalore, Chennai and Pune.

Garuda Access Portal

The latest release of GARUDA Portal version 1.1 supports:

- Sequential and parallel job submission to the Garuda Grid through both Moab Grid Scheduler and Globus middleware
- Heterogeneous MPICH job submission through Globus
- Viewing job status and output
- Viewing available resources
- Multiple application specific input, output and error files
- Facility to submit the RSL file explicitly or automatic creation of RSL



Garud Access Portal

Workflow Solution for Garuda Grid

A workflow solution for Garuda grid has been provided by leveraging on the open source Triana software. Workflow is an important development environment for the grid as it helps to build larger composite distributed systems by capturing the constituent tasks in an ordered fashion. Using this setup, a workflow was prepared for the Disaster Management Application of Space Application Center, ISRO, Ahmedabad and successfully demonstrated.

GARUDA Sigma

Garuda Sigma is a sophisticated grid installation package, conceived with an aim to unify all the tasks of installation and configuration of Garuda grid related software. It bundles up all the base software, grid middleware and CDAC grid suite for both Cluster Head nodes and Compute nodes into a single package that can be installed at any site. This software is especially useful to the system administrators at Garuda partner sites and the Garuda deployment team.

GARUDA Sigma was officially released to all the Partners in the Second Garuda Partners' Meet in Sep 2006. CDs containing Garuda Sigma were given to each participating institute during the System Administrator Training Program held in April 2006.

Network Simulation for GARUDA

C-DAC continued Garuda network simulation. The modeling and validation of GARUDA communication fabric, workload modeling, and some of the applications have been completed. The following documents and reports have also been completed:

- Network simulation for GARUDA: Modeling and validation of GARUDA communication fabric
- Network simulation for GARUDA: Network workload modeling
- Network simulation for GARUDA: SLA violation predictions
- Network simulation for GARUDA: GridFTP optimizations

Comparative analysis of various routing protocols on GARUDA communication fabric and implementation of BGP confederation are activities under progress.

Integration of C-Crypto with Globus

The integration of C-Crypto with Globus has been completed.

Centralized Firewall Management for Garuda

The project proposal was conceived and presented for approval. Currently, the prototype implementation is under progress.

Storage Resource Broker (SRB) – A Data Grid Solution

Nirvana Storage Resource Broker is a data grid implementation, powerful yet easy to-use software that enables researchers, developers, and other knowledge workers in collaborative groups to discover, share, and manage files through transparent and unified interfaces. The SRB agents were deployed at select locations and SRB was integrated with GARUDA to provide seamless access from the GARUDA Portal. SRB Data synchronization was configured for disaster recovery between Pune and Bangalore.

EU India Grid Project

The European Commission funded project entitled “EU India Grid” joining European and Indian grids for e-science network community started from October 2006 with participants primarily from research institutions from Italy and India. The primary objectives of this project are to:

- Support the interconnection and interoperability of EGEE grid and Indian Grid for the benefit of eScience applications
- To identify and aggregate research, scientific and industrial communities resulting in an eScience Network Community published on the EU-India grid portal

C-DAC's Supercomputing Facilities

In addition to building state-of-the-art supercomputing systems, C-DAC has also built two state-of the-art supercomputing facilities around the supercomputing systems launched by it in 1998 and 2002. The former facility at Pune is known as National PARAM Supercomputing Facility (NPSF) and the latter at Bangalore is known as C-DAC's Terascale Supercomputing Facility (CTSF). NPSF was built around the PARAM 10000 system while CTSF was built around the PARAM Padma system. Both the facilities provide secured remote access to their respective PARAM systems to the users in various parts of the country. Several users requiring supercomputing power to solve their scientific and engineering problems have thus used the supercomputing systems at NPSF and CTSF.

NPSF at C-DAC, Pune

The PARAM 10000 system at NPSF had reached its end-of-life after having been used extensively for almost eight years. In order to continue meeting the demands of NPSF users, two additional clusters were set up at NPSF during the year:

- A 16 nodes, dual Intel Xeon based system (total 32 processors). It has 48 GB main memory and Gigabit Ethernet interconnect
- A 17 nodes, dual-core AMD dual Opteron processors based system (total $17 \times 2 \times 2 = 68$ cores). It has 68 GB main memory, and state-of-the-art Infiniband interconnect

A 4 terabyte storage was kept common to both AMD and Xeon clusters to allow users' data and programs to be accessible (shared) from both, enabling ease-of-use of the two clusters.

Both the clusters were suitably enriched with systems software components like tuned MPI, parallel and serial versions of math/numerical libraries, batch processing system, and debit model based accounting and allocation manager. Applications demanding large I/O often perform poor on such clusters typically because the I/O performance of the clusters remains neglected. In order to alleviate this, two parallel file systems were setup and provided to the cluster users – PVFS and LUSTRE. Both these file systems allow users to take advantage of the underlying infrastructure without even recompiling their applications. Merely accessing the input or output data which resides on these file systems provides a higher I/O performance.

In order to keep a user well informed about the status of his jobs running on these clusters, the batch processing system was integrated with GSM mobile-based messaging system. The users now receive the job status information as SMS on their mobiles in addition to e-mails. This messaging solution is also used to provide the systems status to the systems administrators so that whenever problem occurs, the concerned systems administrator is immediately informed by SMS and thus allows immediate rectification of the problem.

CTSF at C-DAC, Bangalore

There has been rapid increase in demand for the PARAM Padma resources due to the rising number of technical affiliates and educational institutions joining the CTSF scheme. This prompted the upgradation of CTSF with an additional 1 Teraflop compute power (160 POWER5 CPUs) and 5TB storage.

HPC Applications

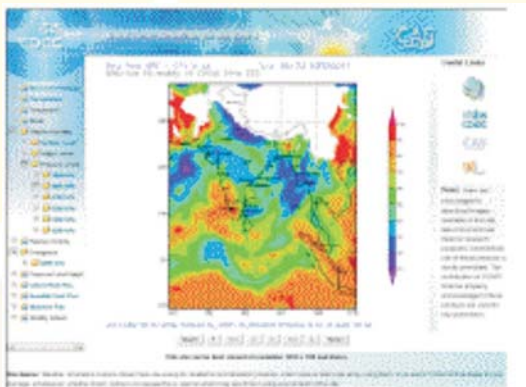
Computational Atmospheric Sciences (CAS)

Air quality simulation for Pune city using WRF/ Chem model was carried out. This model simulates both chemical interactions as well as transport of the chemical species over selected model domains. The 3D grid inventory with grid spacing of 2 Km X 2 Km for the year 2005 was prepared and used to simulate PM₁₀ dispersion over Pune region (for a period April 11-19, 2005). This experiment is expected to help in understanding the urban pollution dispersion and usefulness of this model in urban air quality research. A Linux interface for AERMOD model and an offline version of atmospheric chemistry WRF/ Chem model (in collaboration with NOAA/ FSL, USA) have been developed.

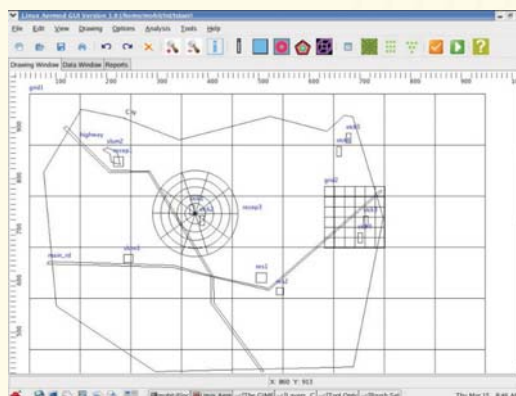
This year, for monsoon prediction, the focus was on trying to understand the biases in the model and rectify them if possible. Use of existing physics schemes in the model was explored and an attempt was made to modify them. The model was run with two cumulus schemes, simplified Arakawa Schubert scheme (SAS) and relaxed Arakawa Schubert scheme (RAS). The RAS scheme enabled simulation of the monsoon more realistically than the SAS scheme. The model has been run for twenty years to generate the climatology of the model. In regional coupled ocean-atm project (DST), three atmosphere regional models MM5, RegCM3 and RSM have been run for 15 years using the reanalysis data as the initial and boundary conditions. Two ocean models ROMS and

POM are being run for a period of twenty years using the monthly COADS and Levitus data to get the model spinup.

A project on real time weather system (RTWS) involving development and release of real time weather system product for daily 72 hours forecast for Indian region using C-DAC's PARAM system was carried out. The fully automated system gives high-resolution web based weather forecasts useful for researchers, aviation industry, and air quality management and decision makers.



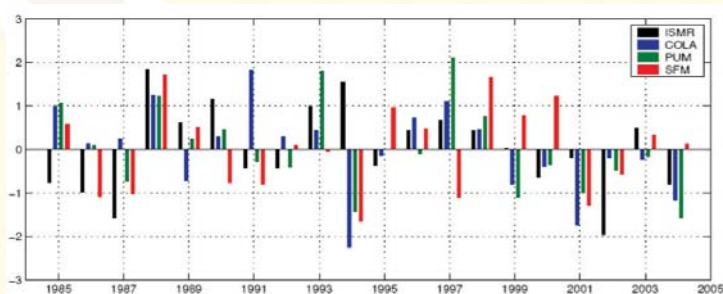
Real time weather system



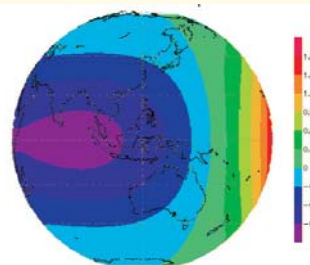
Linux AERMOD GUI

A turnkey service project for Andhra Pradesh state disaster management society (APSDMS) was completed. A preprocessor to initialize PUM model with Global Forecast/ Analysis data from NCEP/ NCAR has been developed. WRF-AERMOD, a workflow implementation across heterogeneous grid infrastructure comprising Unix-based WRF and windows-based AERMOD application, has been developed.. This system runs WRF for the entire period, followed by subsequent runs of WRF2AERMOD coupler, AERMOD, and post processing. C-DAC is participating in the EUIndia grid project as a stakeholder in the Earth and atmospheric science grid applications. It is also collaborating with 'Physics of weather and climate' group of Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy for regional coupled atmosphere-ocean model.

C-DAC has also been involved in a project on seasonal prediction of Indian monsoon (SPIM) in collaboration with Indian Institute of Science, Bangalore. The scope of this project is to assess the skill of various atmospheric general circulation models (AGCMs) used in the country for seasonal forecasting of Indian summer monsoon. Porting of the AGCMs on the PARAM Padma has been completed. NCEP SFM (IISc/ IMD), NCMRWF T80 for extended range prediction (NCMRWF), Varsha GCM for seasonal forecasting (NAL), portable unified model (IITM-Pune), COLA AGCM (IITM-Pune), and ECMWF GCM (IIT-Delhi) have been implemented on PARAM Padma. Different modeling groups across the country provided the initial conditions for the respective models for the years 1985–2004. The post-processing tools of these models have been implemented on PARAM Padma. CRAY to IEEE converters and post-processor for COLA GCM have also been developed.



Observed and simulated variation of all-India rainfall: 1985-2004

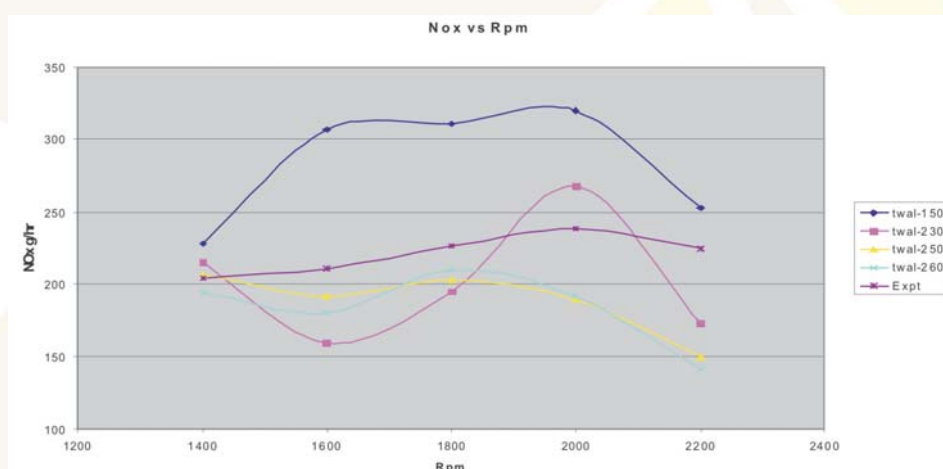


Helmholtz solution on sphere

Research work on atmospheric model kernel development has been initiated. The core of atmosphere/ ocean models is based on the PDE solvers on the spherical geometry. The group aims to work on a dynamical framework for creating variable resolution with global spectral method based on high-resolution tropical belt transformation. High-resolution tropical belt transformation produces finer resolution over the tropical regions of the globe. This will in turn enable to resolve the monsoon cycles, El-Nino cycles with finer resolution. A prototype variable resolution Helmholtz solver has been developed.

Computational Fluid Dynamics (CFD)

A project on optimization of internal combustion (IC) engine (M/s Escorts Ltd, Faridabad) using KIVA-3V, a special purpose CFD code for performing IC engine simulation, and genetic algorithm for performance optimization is at results validation phase. Simulations at different wall temperatures ranging from 150 deg C to 260 deg C (150, 200, 230, 250, 260 deg C) for each rpm (ranging from 1400 to 2200) have been carried out. Simulation results for NO_x, CO, and HC emissions at cylinder wall temperatures equal to 150 deg C are found to be close to the experimental trends.



NO_x Generation rate at different wall temp

A project on thermal analysis of a 10G SAN switch for understanding heat dissipation characteristics and hotspot locations inside the switch box through CFD simulation has been carried out. This study has enabled analysis of the flow velocity and, temperature and heat transfer behavior in electronic components, boards and complete systems. A scale-up study was conducted to benchmark PHOENICS CFD software on Xeon Cluster. A simple case of flow around the buildings was considered for this study and the parallel simulation was performed for 200 iterations with a grid size of 12,56,850. Similar study was conducted to benchmark CFDExpert with a grid size of 47385 points.

A simulation, using PHOENICS package, of the flow field around protrusions was performed. A parallelepiped protrusion of the dimensions of 23 x 12 x 9 mm with 90 deg leading edge angle was considered for this study. The protrusion was subjected to a compressible flow at Mach 2 (~700 m/s). Many complex features like flow separation and bow shock wave formation were successfully visualized and were in good agreement with the experimental observations. The pressure variations captured the shock wave at nearly same location as those found during experiments.

Computational Structural Mechanics (CSM)

A joint project on optimization of laminated fiber reinforced composites on parallel platforms, in collaboration with IIT-Guwahati (funded by DSM) has been completed. Work on static and dynamic finite element analysis software development and its interface with parallel genetic algorithm code has been carried out. Various parallel strategies have been implemented on PARAM Padma systems. The project objective has been achieved and the research outcome can be offered as a solution to potential users.



Case Studies for Earthquake

C-DAC has initiated an earthquake research grid in India (ERGI) concept, where the objective is to offer solutions and services on earthquake engineering and high performance computing to structural engineers and researchers to help them in designing better earthquake-safe structures. Under this activity, C-DAC has entered into a collaborative project with SGSITS-Indore on computer aided seismic analysis and design of concrete structures. The modules for structural elements like beam, column, slab etc. have been developed during the past six months. Under ERGI activity, OpenSees, public domain earthquake engineering software has also been made available, and testing and validation studies have been carried out.

C-DAC has carried out integration of various modules developed for FRP structural analysis and named it as INTCOMP software (earlier COMPOSIT). A similar displacement model for different analyses as static, dynamic, impact has been implemented for the benefits of the users. C-DAC was also involved in testing and benchmarking activities of software such as FRACT3D and SMART on PARAM systems at NPSF/ CTSF and through problem solving environment (PSE).

Seismic Data Processing (SDP)

The Phase II of the INVWAV project was submitted to ONGC and it has formally been accepted. It involves fine-tuning and enhancement of the current software to process real data of Seismic Full Waveform Inversion (INVWAV). The project (in collaboration with NGRI) on seismic traveltime tomography (SEISTOM) with real field data is in progress. A new project for 3D depth imaging has been submitted to DST in collaboration with NGRI. Development of GUI (WAVES-II) is in progress for all the Modeling and Migration codes developed earlier so that they can be accessed from one platform and in a user-friendly way.

A project proposal on 3D seismic modeling in collaboration with ICAD Russia has been submitted under the ILTP scheme. Binary coded genetic algorithms have been implemented in SEISTOM. Work on seismic inversion using simulated annealing has been initiated.

Bioinformatics

A GIPSY portal to access bioinformatics resources and applications facility (BRAFI-II), a DIT funded project, has been enhanced and updated. In the grid-enabled Smith-Waterman code project, work on deployment of the portal through the Garuda grid setup across four geographically distributed locations has been completed. Access to applications like Fasta, ClustalW, Blast and Amber has been developed. Hardware reconfigurable computing (RC) card for speeding-up the Smith-Waterman (S-W) algorithm, has been developed. S-W algorithm, used for detecting pair wise optimal local alignment with high sensitivity, requires $O(m \times n)$ time and memory for the sequences of length 'm' and 'n', respectively. The RC card developed *in-house* can be plugged into any desktop computer. Using nucleotide and protein sequences with varying sizes of query and database, speed-ups up to 30-66 folds have been observed.

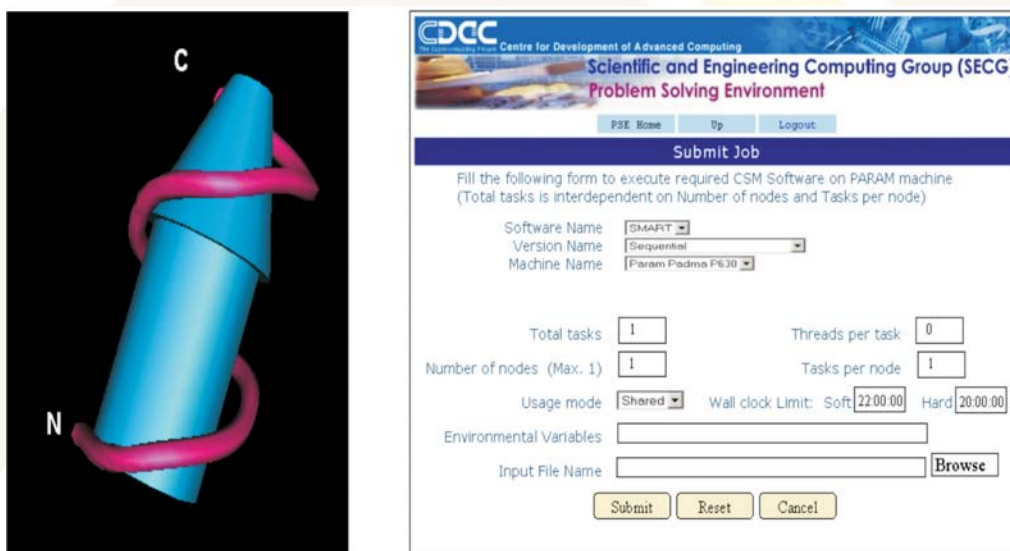
A DBT funded project, EST analysis of mosquito genome, has been initiated. *Anopheles stephensi* is the major vector for malaria in India; however, its genome sequence is not yet available. Expressed Sequence Tag (EST) sequencing is an economically feasible alternative for gene discovery in species lacking a draft genome sequence. Work has been initiated on development of

high-throughput computational workflows for genome analysis. Evaluation of the existing Bioinformatics workflows has been carried out. Freely available public domain workflows viz., Bioclipse, Wildfire, Taverna, PegaSys, Biopipe, Biowep, MIGenAs, BioWBI and CARMAWeb as well as commercial tools such as UberTool, Biosuite, and VIBE have been evaluated extensively.

C-DAC has been involved in several research activities such as protein folding, microarray data analysis, mycobacterium comparative genomics, reconstruction of metabolic pathways, phylogenetic profiling of genes to detect functional linkages, building of molecular docking pipeline, and Nicholas Piramal research centre (NPRC) project on molecular dynamics studies to understand flexibility of residues in the binding pocket of a protein, amongst others.

Evolutionary Computing (EC)

An in silico protein polymerization using Monte Carlo techniques is being explored by considering Alzheimer's disease as a case study (a neuro degenerative disease that occurs by polymerization of Amyloid b-peptide). A serial as well as parallel genetic algorithm (GA) library, which can be used in any optimization problem, has been developed. Taguchi's method based on orthogonal arrays has been employed to accelerate the optimization process by more than two times in some of the benchmark problems. A graphical user interface is implemented for user input, visual output and for job monitoring. A traveling salesman problem-solving tool has been developed using both GA and Ant colony. Island model is implemented in GA to improve its performance and applied to fibre reinforced plastic structure optimization. An implementation of evolutionary strategy algorithms has been completed. Evolutionary strategy is an optimization technique based on the ideas of adaptation and evolution.



A project on developing different hybrid methods for protein structure prediction (PSP) using genetic algorithms and Monte Carlo methods has been completed. A Linux-based version of the problem-solving environment (PSE) for scientific and engineering applications was completed.

Other HPC Activities

PARAM for Triple-play Services

Under Private-Public Partnership arrangement, C-DAC and DiviNet developed technologies for TV centric triple-play services offering voice, video and data services. This activity was carried out under the New Millennium Initiative for Technology Leadership of India (NMITLI) scheme of Dept. of Scientific and Industrial Research (DSIR) funded by the Dept. of Science and Technology (DST). Based on the developed technologies, BSNL launched its Multiplay Services on Broadband at the hands of Shri A. K. Sinha, Chairman and Managing Director, BSNL on March 15, 2007. The event was presided over by Dr. R. A. Mashelkar. The launched service is powered by C-DAC's indigenously designed, developed, and deployed PARAM Sarita System. This high-end multimedia

server system is designed for applications like Video-on-Demand and Interactive TV as the backend server for the offered services. C-DAC's Graphics and Intelligence Based Script Technology has contributed towards developing multilingual TV interface for this solution.

HPC Clusters Setup

In addition to its in-house efforts of setting up of PARAM clusters, C-DAC has also helped several research, academic, and other institutions in setting up of HPC clusters in their own premises for their dedicated use. Some of the HPC clusters setup during the year by C-DAC are:

- **HPC Cluster at NIO, Goa.** At NIO Goa premises, a smart card enabled desktop-based thin client solution has been established for various administrative and scientific research departments along with establishment of a gigabit backbone to support IP telephony. Systems and Application level support is ongoing for the HPC cluster being used extensively for ocean modeling and research purposes.
- **HPC Cluster at IIT, Delhi.** An HPC facility with 18+1 Opteron-based nodes has been deployed in the Computer Science Dept. of IIT Delhi, which shall act as a Grid Resource also. Additionally, the deployment of a high performance storage solution of 22 TeraBytes has been just completed, which C-DAC had won through a tender.
- **HPC Cluster at Haryana Agricultural University.** An 8-node Opteron based Linux cluster has been installed at Haryana Agricultural University, Hisar. This cluster is aimed at running Bioinformatics application codes.
- **HPC Cluster at NCL, Pune.** A 4-node Opteron based Linux cluster was deployed at Chemical Engineering Dept. of NCL, Pune for conducting research in Chemical Sciences. C-DAC has also signed a MoU with PRL, Ahmedabad for HPC deployment and on-site application support wherein the design phase is in progress.
- **Disaster Recovery Setup to SBI.** C-DAC has provided consultancy services to State Bank of India (SBI) in the past and carrying forward this association, it has provided consultancy for routing equipment evaluation in lab and online environment for SBI Core banking project for Wide Area Network deployment across branch locations. Disaster Recovery setup was also tested between the primary and secondary sites of the Core banking project namely Belapur and Chennai.

Multilingual Computing and Allied Areas

Efforts continued during the year towards enhancing the features of existing tools and technologies and initiating development of several new tools and technologies in multilingual computing and allied areas. The activities carried out during the year along with some significant achievements are described below.

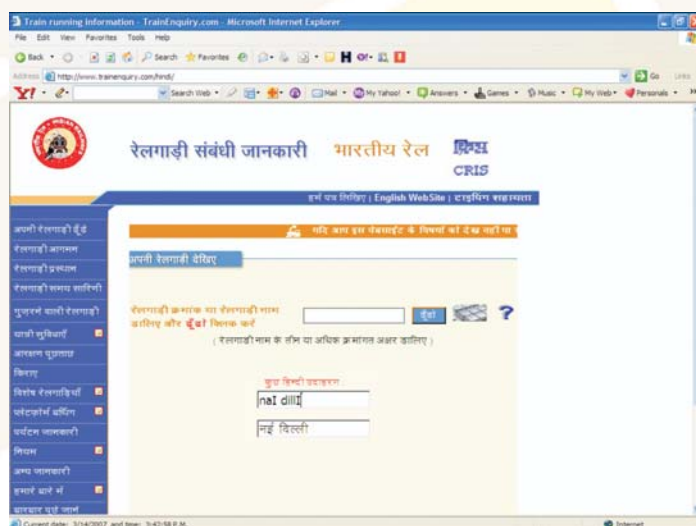
Localization Frameworks

Localization frameworks have been developed for:

- **Data and Code Conversion.** It uses a translation memory cum rule-based approach to do the conversion and is also backed up with a synonym dictionary and a customizable GIST dictionary suite. Currently it supports VB or VB .net code for localization. HTML/ ASP/ ASPX pages of existing English application can also be converted to Indian Languages using this framework. It retains the physical layout of the web page and enables Indian Languages without changing the layout or the look and feel of the web page.

- **Browser Plugins Based Web Page Conversion.** It enables conversion of English web pages to various Indian Languages like Devanagari, Tamil, Punjabi, etc. at the client side. The conversion does not affect the layout or advertisements of the page. Conversion is also possible between Devanagari and Urdu. This functionality has been integrated with iPlugin Toolbar that sits within the IE and Mozilla browsers and acts as a localizing agent.
- **Existing Desktop Applications Conversion.** It enables localization of all labels, menus, etc. of existing applications into Indian languages. The conversion and change happens in memory and provides an Indian language skin to an existing application. This avoids the need to recompile the software.
- **English-to-Hindi HTML Converter.** It enables bulk conversion of English HTML pages to Hindi. It uses a Translation Memory based approach for localizing the given folder. The folder is scanned for all existing Web pages to which the processing logic based on rules of domain specific terms and terminologies, followed by transliteration is applied. Acronyms are also handled by this utility.

Using the localization frameworks mentioned above, the train enquiry web-application has been successfully localized to Hindi and deployed. This activity has been carried out under the *Rajyabhasha Information Technology Application Promotion Program (RITAP)*.



Rajyabhasha Information Technology Application Promotion Program (RITAP)

The application contains static and dynamic data in the form of information about trains and their schedules. In addition to display of information, user interactions in the form of queries and search facility have been provided in Hindi. This information is taken from a backend database and converted to Hindi using GISSQLTools and displayed through web pages. Currently the activity of migration of the application further to Unicode has been undertaken by C-DAC. The Hindi Solutions have been provided to the entire architecture. The URL for Hindi Website is [http:// www.trainenquiry.com/hindi/](http://www.trainenquiry.com/hindi/)

Productivity Enhancement Tools and Technologies

Advanced Search Engine

A very powerful and unique search engine plug-in has been developed. It takes care of following while searching Indian language contents:

- **Legacy data:** has facility of converting legacy data to Unicode / ISCII for search.
- **Language identification:** has a module for language identification. This is important since close to 30-40 languages are represented using Devanagari script.

- **Inherent Complexities of Intra-word Grammars:** Because of the complex inflectional or agglutinating nature of Indian Languages and also because the word is the root accompanied by its inflections, in certain cases a single word can admit as many as 30-50 forms.

हिंदी हिन्दी

- **Spelling Variants.** The word Hindi can itself be spelled in two ways.
- **Incorrect spellings:** Spellings have yet to be normalized and hence the average user enters the word very often incorrectly.
- **Multilingualism:** Indian users of the search engines are very often bi-lingual and would like to ensure that the search is conducted within more than one language. A Gujarati speaker would like to search also in Hindi. Such cross-lingual information retrieval is the order of the day for Indian users of the web.
- **Synonymic Search:** Historically Indian languages have seen cross-cultural impact with the result that a word has many synonyms. To ensure that the search is relevant, all possible synonyms would have to be provided.
- **Polysemic Search:** As with all languages, a word can admit polysemy and belong to different domains. A polysemic search would ensure that the user could narrow down his search to a relevant area instead of being confronted with a large amount of data, which is irrelevant and based on ranking algorithms.
- **Natural Query:** Apart from those familiar with Boolean operators, users normally expect the Web to work like an Information bureau with queries being addressed in natural language. A person who wants to know the price of potatoes in Punjab would simply state: What is the price of potatoes in Punjab? (Very often misspelt) and expect an answer to his query.

At present, the searches are restricted to Hindi, Marathi, Gujarati, and Oriya. Bangla, Malayalam, and Punjabi are under development. Tamil, Konkani, Kannada, and the remaining official languages are to follow.

Spell-Checkers

C-DAC has to its credit the development of the first Indian language spell-checkers under both DOS and Windows. The existing spell-checkers have been revamped, and a new and dynamic algorithm permits for a faster and more efficient spell-check. The existing dictionaries have been upgraded and the new dictionaries are richer and have more words and have been updated to suit the requirements of the present day world where spell-checkers are needed for the web. A new Urdu Spell-checker *Imla Shanaas* has been released. Efforts are also on to develop a Bangla spell-checker.



Grammar Checkers

A prototype of a first-ever Grammar checker for Hindi has been developed by C-DAC. The design of the checker allows for easy adaptation to other languages. It can be used to not only validate incorrect grammar within text but also and more importantly, permit the user to ensure that the correct grammatical forms have been used. It can also be used by school children to master the intricacies of Indian language grammar.

The Grammar Checker developed using the base of GIST technologies and linguistic resources handle the following cases: Concord at the N.P. Level, and V.P. level.

Lemmatizers

Lemmatizers are necessary for higher-level NLP, especially if the word has to be correctly tagged as to its categorical class. C-DAC has developed Lemmatizers, which have a wide range of applications in areas as diverse as Translation, Semantic Web, Data Mining, Natural Query Systems, to name only a few.

Microconverters

Ongoing research on script grammars has resulted in converters which are bi-directional and can move from storage to display and conversely with a single DLL. A single generic engine handles all the converters, which are rule driven and extremely tiny in size. Thus the converter for Devanagari is around 1.8 KB with an engine size of 12 KB. This allows for easy and fast conversion both on Websites where hack fonts are used as well as for embedded devices, which are memory hungry.

Domain Based Dictionaries

The linguistic resource cell has been instrumental in creation of domain-based dictionaries, thesauri across all 22 Indian languages. The language rule based routines are capable of handling acronyms as well as address fields.

Cross-Lingual Information Access (CLIA) System

C-DAC has worked on NLP based Information Extraction/ Retrieval (IE/IR) technology development. This effort has resulted in two systems –

- A prototype system for web and mobile platforms namely Quester Cricket Information Retrieval System (QCIRS), and
- Setu, a CLIA from English to Hindi for translation and traditional search engine for web search.

Efforts to enrich these systems continue. Additionally, C-DAC is participating in the development of a CLIA system as a consortium member of a consortium of 11 institutes. The work components of C-DAC consists of development of Font Recognizer, Meta search engine, parallel and distributed search, soft keyboard and other corpus related activities.

BharateeyaOO.o

OpenOffice.org is one of the pioneering efforts to develop a full-fledged Globalized Office Suite with all the features of platform independence and language independent APIs, by integrating the efforts of developers all over the world. C-DAC is contributing to this project in the localization and internationalization of OpenOffice.org in Indian Languages, to develop the first Office Suite to be fully supporting all the main languages in India.



Inditor

Inditor, an online editor in which a user can input various Indian Languages is being developed. Respective fonts are not required in the operating System. All the basic functionalities such as cut, copy, paste, redo, undo, go to line search are available. The GUI Interface can also be changed from English to the Indian Languages. The text file can also be saved in the system.

Manuscript Editor

A manuscript editor called *Pandu-Lipi Samshodhanka* is being developed. The functional modules of the system cover acquisition, formatting, inputting, indexing, creating database, searching, locating, printing, collation and publishing. Tools have been developed for acquisition of (around 3500 pages) rare manuscript images from different libraries/ resource centres. Visits were made to various Oriental Manuscript Libraries at Thiruvananthapuram, Chennai, Ujjain, Mysore, Chandigarh, Pune and interacted with others at Wai, Kolkata, Varanasi, Tirupati, Baroda, Thanjavur etc. for collecting rare palm-leaf manuscripts for analysis.

Development of Sanskrit Learning CD (Swadhayaya) – first volume out of five has been completed. Work for second volume is in progress. Possibility of Text to Speech for Sanskrit and need to enhance from I-TRANS to ISCI input, with more wave samplings is being explored. Application has been developed for Shadvimshati sutra and SaptaLakshanam rule analysis. Reference source linking for Sroutam text in Kalpa Application program has been done.

Machine Translation Systems

MaTra2

An English-Hindi Machine Translation system for translating unrestricted text, MaTra2 is an ongoing research project that aims at providing indicative translations for general-purpose usage and could be used, for example, to provide on-the-fly rough translations of English documents on the web. MaTra2 is designed to be robust and to work reasonably well even when faced with incomplete sentences, erroneous constructions, unknown words, etc. MaTra2 uses state of the art tools and techniques, incorporating both statistical and rule-based methods to perform the task of translation. MaTra2 is also being used as the translation engine in the CLIR system being developed at C-DAC.

MANTRA – Rajbhasha

Under this project domain based English to Hindi language translations are already catered and implemented for Administration, Finance, domains. On September 14, 2006 during the Hindi Diwas celebrations Shri Shivraj V. Patil, Hon'ble Union Minister for Home Affairs, Govt of India launched Mantra-Rajbhasha Translation system for Agriculture and Small Scale Industries domains. Currently work is in progress for developing translation system for Health and Information Technology domains.

The software is available on CD, Intranet, and Internet versions. The website for online translation is <http://www.mantra-rajbhasha.cdac.in/mantrarajbhasha>

English to Indian Languages Machine Translation (EILMT) System

Work is in progress on the development of EILMT system. This is a two-year project being implemented by a Consortium of 10 institutes and C-DAC is the Consortium Leader. The domains are Tourism and Health care and the translation language pairs are English-Hindi, English-Bangla, English-Marathi, English-Tamil, English-Oriya, English-Urdu.

A Statistical Machine Translation (StatMT) system is being developed as part of this initiative.

Indian Languages to Indian Languages Machine Translation (IL-ILMT) System

C-DAC is participating in the development of IL-ILMT System as a consortium member. This is a two-year project being implemented by a Consortium of 12 institutes. The domains are Tourism and Health care and the translation language pairs are Tamil-Hindi, Telugu-Hindi, Marathi-Hindi, Bengali-Hindi, Tamil-Telugu, Urdu-Hindi, Kannada-Hindi, Punjabi-Hindi, and Malayalam-Tamil.

Character Recognition Tools and Technologies

Optical Character Recognition

C-DAC has successfully developed a commercial product “Chitrangan” for recognizing printed matter text for Devanagari script. As a part of the newly formed consortia, C-DAC is involved in its optimization, packaging, and commercialization activities. The application is targeted to Linux Platform.

C-DAC has also developed an OCR system for printed Malayalam documents with reformed Malayalam script. It can recognize a glyph set of 250 characters with an accuracy ranging from 85-97% depending on print quality. Efforts are now on to develop an OCR system for printed documents with traditional Malayalam script consisting of about 1000 characters.

Efforts are also on for developing an OCR system for Bangla printed text.

Online Handwriting Recognition System (OHWR)

With the advent of mobile computing, various text-inputting mechanisms have been proposed and implemented but for Indian languages, these still lack the simplicity and speed. To simplify human machine interaction, C-DAC is working towards Online Handwritten Character Recognition and has obtained promising results in the lab. C-DAC has developed a proof of concept of an Online Handwritten Character Recognition engine for mobile devices in Devanagari. Similar work is being carried out for other Indian Languages.

Building on top of the existing OHWR technologies already developed, which included a stroke based recognizer for Hindi, C-DAC is contributing towards OHWR consortia project, starting with corpus collection. It gives a decent accuracy for handwritten text including Devanagari numbers, Basic strokes, and syllables. Now, under the consortia project funded by DIT, C-DAC is enhancing the existing Online Handwriting Recognition system.

Efforts are also on for developing a Hand-written Character Recognition System for Bangla script.

Robust OCRs for Printed Indian Scripts

A Consortium of 11 Institutions with IIT Delhi as Consortium Leader is implementing this project. The specific aims of the project are: (i) To Develop robust OCRs for printed Indian scripts which can deliver desired performance for possible conversion of legacy, printed documents into electrically accessible format (ii) The integrated OCR system will be developed for Bangla, Devanagari, Malayalam, Gujarati, Telugu, Tamil, Oriya, Tibetan/ Nepali, Gurmukhi, Kannada with font and point size independent recognition capability. C-DAC is working on the layout retention and integration process. The document for the first version of the design of software architecture for layout retention module has been delivered. A website has been developed: <http://www.cdacnoida.in/ocr>

Web Based Tools and Technologies

World Wide Web (W3C) Standards

C-DAC was assigned the project of studying and evaluating a large number of standards proposed by the W3C, which is a recommendatory body for standards pertaining to a large number of crucial issues such as XML, Semantic Web, Mobile Web, etc. The following standards and norms (recommendations in W3C terms) were assigned: Character encoding issues, Locale specific data, Internationalizing domain names, NamePrep StringPrep Profile for IDN, PunyCode Bootstring encoding for IDNA, StringPrep, Path of IDN, Text formatting issues, Determining Language Names, Font and rendering issues, Internationalization tag set, Mobile Web Initiative.

Various case studies have been undertaken for CSS ITS and Mobile Web Initiative and recommendations for Indian Languages. The resulting recommendations will be useful in implementation of e-Governance web applications in Indian languages.

A web site has been developed for W3C India office (<http://w3cindia.in>) to proliferate awareness about W3C so that the Indian Industry and research institute participation will increase in evolving web standards for the future. Several W3C documents are being translated in Hindi and Indian languages.

W3C partners with regional organizations wishing to further W3C's mission by establishing local W3C offices. These W3C Offices assist with promotion efforts in local languages, help broaden W3C's geographical base, and encourage international participation in W3C Activities. W3C Indian office has been set up at C-DAC – the 15th office worldwide. It has now 12 members from India.

Subscribers of w3cindia.in are sent a Bilingual Monthly Newsletter on latest news on technologies and standards being evolved at W3C to update them on latest happenings. There are around 200 subscribers to the Indian website.

Internationalized Domain Names

The Department of Information Technology, Govt. of India, has decided to Implement IDN in .IN registry for all 8th schedule languages mentioned in the Constitution of India, now totaling 22 in number. Tamil and Malayalam will be launched first followed by Hindi and other Indian languages.

Various Registrars have been authorized for taking up the registration process. For registering an IDN, the registrars should be

provided with Language tables, variant mapping tables, and IDN registration policies for that particular language. This project involves study of the requirements for the IDN registry, preparation of the required documents for IDN registration and provides support to the Registrars for the implementation of IDN for the .IN domain.

C-DAC played a pivotal role in implementation of the IDNs for Indian languages. Under the project variant tables for Hindi, Marathi and Urdu were prepared along with the policy for implementation of IDN. The project dealt with having Domain names (eg: cdac.in) in local languages. Extensive research was carried out on Punycode as well as Homoglyphs and Homophones in various languages including Urdu to prevent Spoofing and Phishing, which are major causes of online fraud. Hindi and other languages IDNs are going to be implemented soon.

Language Learning on the Internet

Continuing its development and deployment of language learning software on the Internet, C-DAC successfully launched its Learn Indian Languages through Artificial Intelligence (LILA) Hindi teaching software through Manipuri, Oriya, Marathi, and Assamese languages. The three Hindi courses Prabodh, Praveen, and Pragya can now be learnt on the Internet by selecting Manipuri, Oriya, Marathi, and Assamese languages as the medium of instruction. The packages were dedicated to the nation by Shri Shivraj V. Patil, Hon'ble Union Minister for Home Affairs, Govt. of India on September 14, 2006 during the Hindi Divas Celebrations, at Vigyan Bhavan, New Delhi. The packages can be accessed online at the website <http://lilapp.cdac.in>

COIL Net

The aim of CoilNet project is to generate and create more Hindi content on the web. Amongst the deliverables of C-DAC - the Enhanced Transliteration and Dictionary Tagging tools were developed and deployed in the current year. The Enhanced Transliteration Tool enables users to transliterate text files between Hindi and English over the Internet. The Dictionary Tagging Tool is a linguistic resource generation tool, which supports morphology, lemmatizer, for Hindi nouns. A font independent engine, which works from IE, Mozilla on Windows, Linux as well as MAC Operating systems, was also developed and is available online. The dictionary tool assists in creation of dictionaries online and linguistic resources. Tagging Tool is a database oriented tool which allows a user to enter a word with all its grammatical details like Etymology, Class, Gender, Denotative Meaning, Connotative Meaning, Domain Based Meaning, Collocations, Inflectional forms, etc.

TDIL Data Centre

A portal for resources and tools in Indian languages has been developed. The tools, fonts, software developed by different resource centres and institutes for Language Technology for different Indian languages have been made available for download. The user of this portal is provided with tools in different Indian languages with Interface in local language. The user can request CD, download tools, register on website and provide his feedback. The FAQ and solutions to common problems encountered are disseminated through website as well. The entire portal has been made online at two places and attracts good user traffic as per the analysis. The



Speech Technologies

Matrubhasha

Matrubhasha provides a Rule-Based TTS system for Indian languages. For Speech Synthesis, Matrubhasha uses Mbrola – a speech synthesizer based on concatenation of diphones, which is developed by the TCTS lab of 'Faculte Polytechnique de mons' (Belgium) and provided free for non-commercial applications. It takes a list of phonemes as input, together with prosodic information (duration of phonemes and a piecewise linear description of pitch), and produces speech samples on 16 bits (linear), at the sampling frequency of the diphone database used.

Matrubhasha aims at synthesizing speech from a given Unicode input, by converting it into a list of phonemes, together with prosodic information in the format required by Mbrola speech synthesizer. Matrubhasha also aims at providing plug-ins with TTS functionalities for commonly used software applications like Office Applications and Internet Browsers. Matrubhasha is also working towards emotional speech output, which sounds more natural.

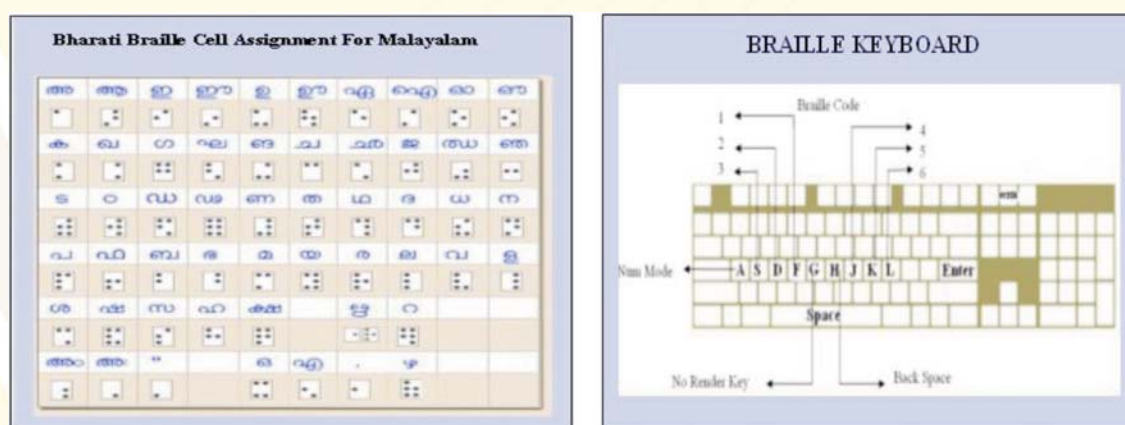
Matrubhasha Speech Recognition efforts will be concentrating on building command and control (C&C) engines. Dictation engines will be built after considerable headway is made into building C&C engines for Indian Languages. Matrubhasha project has adopted CMU Sphinx for Java and ISIP ASR Software for C/ C++. C-DAC's achievements in the Speech Synthesis area enable the process to follow a similar model in Speech recognition. Matrubhasha ASR will build products for different kinds of users ranging from the layman to software developers to UI architects.

Shrutlekhan - Rajbhasha

Shrutlekhan - Rajbhasha - a Hindi Automatic Speech Recognition system was released by Shri Shivraj V. Patil, Hon'ble Union Minister for Home Affairs, Govt of India on September 14, 2006 during the Hindi Divas Celebrations, at Vigyan Bhavan, New Delhi.

Braille Mozhy

An assistive device for the visually challenged, the BrailleMozhy is an integration of Braille to text and text to speech technologies.



A Braille keyboard driver, with input from a PC keyboard enables the user to create Malayalam text. Using the Bharathi Braille cell assignment for Malayalam, the sixty-three combinations of the six Braille dots are mapped to basic Malayalam characters.

The integrated TTS provides speech support for system functions and external Malayalam files. Additional facilities like, direct Malayalam text output and user controlled editing and text navigation are provided. The product was released by the Hon'ble Chief Minister of Kerala, Shri. V.S. Achuthanandan at a function held at C-DAC on March 12, 2007.

Hand Held Scanner Based Hindi and English Text Reading Machine for Visually Impaired

The project is being implemented jointly by C-DAC and CSIO Chandigarh. The objective of the project is to develop a hand-held, rugged and easy to use PC based Reading Machine for Hindi and English comprising of a hand held scanner, Optical Character Recognition software and Speech Synthesis software to help visually impaired persons to read (listen) normal printed texts from books.

C-DAC was assigned the task of development of the OCR and TTS modules.

The Hindi-English OCR and TTS integrated module has been developed. The Hindi OCR system is converted to DLL form as per the need of the project. A training module has been developed and UNICODE support is extended to the module.

The TTS module takes text as input generated from the OCR module and generates synthesized voice by concatenating pre-recorded units that are stored in syllabic form within the database. TTS involves modules of pre-processing, tokenization, syllabification, search module, synthesis and smoothening modules. Different modules are developed. The syllabification rules are framed and module is ready. The annotated database is being improved for covering all phonetic sounds.

Speech Processing in Bangla, Nepali, Assamese, and Manipuri

Anchoring upon the know-how of the Bangla Text-to-Speech (TTS) System that had been used by the Election Commission to declare the West Bengal State Election, the following R&D activities have been undertaken:

- Time Annotated Speech Corpora for Bangla, Assamese and Manipuri to anchor Speech R&D activities in these languages
- TTS System for the Nepali Language
- Intonation and Prosody Studies for the Bangla Speech
- International Phonetic Association (IPA) Symbol Characterization for Bangla, Hindi and Assamese
- Porting Bangla TTS into a VLSI Gate Array Chip for empowering small footprint devices

Speech Corpora

Several initiatives towards development of annotated speech corpora for various Indian languages are given below:

- **Speech Corpora Resource Centre for South Indian Languages.** The objective of the project is to set up a Resource Centre for Speech Corpora Creation, Annotation, and Maintenance for South Indian Languages: Malayalam, Kannada, Telugu and Tamil. It involves collection of speech corpora from different sources and different contexts for all the south Indian languages, their annotation and maintenance. The collection of the corpora will be in a planned proportion to support both synthesis and recognition of speech.

The different sources identified for corpora collection are:

- Broadcasted news reading (with text) from TV and Radio.
- Reading of selected portions of Text from Fiction, Science books, Newspaper etc.
- Reading of carefully selected set of sentences for intonation and prosodic studies for different classes of sentences
- Reading of non-sense word of individual speaker for signal dictionary

Development of grammatical rules governing speech information from the collected speech corpora, extraction of important acoustic parameters, segmentation, and labeling of different phonemes/ other units of speech and sound also forms part of the project.

The database of developed speech corpora can be used for development and testing of speech recognition and synthesis systems and any other applications in speech Technology area.

- **Annotated Speech Corpora for Hindi, Marathi, and Punjabi.** The objective of this project was to construct a minimum but sufficient speech corpus to generate high quality synthesized speech. To achieve the same a set of phonetically rich sentences, most frequent words, vocabulary words and sentences of various prosodic patterns have been selected. Phonetically rich sentences consist of words having C03VC03 type monosyllables in maximum numbers. These syllables may occur at starting, middle or at end positions in the word or it may occur in isolation.

In the module, 1000 most frequent words have been selected which covers approximately 50% of Speech. In addition, most frequently clustered words also have been taken into its original form thus covering major portion of the total clustered words.

All monetary and temporal expressions with the limited set of words, a vocabulary of unique 250 words was created. The list covered words related to Digits, Days, Months, Years, Time, Quantitative Units, and Currency etc. The type of sentences influences the prosodic patterns. Therefore, a set of about 1000 prosody rich sentences was created with the help of linguists. This set contains sentences reflecting anger, joy, and sadness, question type sentences, negative, command, exclamations, etc.

The project has been successfully completed.

Speech Corpora Website - Microsoft Internet Explorer

Address: http://ldc.in/SpeechCorporaW1/main.htm

GOVERNMENT OF INDIA
FUNDING PROJECT OF INFORMATION TECHNOLOGY

- Annotation of the Speech samples at sentence, words & syllable level.
- Segmentation of the annotated speech & creation of database.
- Development of tool to annotate the speech database.

General Information : This Project is Developed by C-DAC Noida under, the Administration and Financial Support of Department of Information Technology, Ministry of Communication and Information Technology Govt. of India.

Sr.No.	Category	Hindi			Marathi			Punjabi		
		Recording	Annotation	Total	Recording	Annotation	Total	Recording	Annotation	Total
1	Most Frequent Words	1000	1000	1000	970	970	970	3960	5000	5000
2	Most Frequent Conjunct Words	1017	976	976	590	590	590	1180		
3	Vocabulary	246	246	246	360	360	360	720	224	224
4	Vocabulary Sentences	251	251	251	204	204	204	408		
5	Scientific Text(Dynamo)	98	98	98	661	661	661	1322		
6	Sentences of News	18	18	18						
7	Prosody Rich Sentences	536	536	536	1031	1031	1031	1062	1515	1515
8	Sentences with Verbs	1073	1073	1073						
9	Sentences of Most Frequent Words				1045	1045	1045	2090	1463	1463
10	Phonetically Rich Sentences								422	422
11	Sentences of Book								5500	5500
12	Sentences of Introductory Punjabi								847	847

Note: For the Restricted Distribution only.

- **Annotated Speech Corpora for Hindi, Bengali, and Manipuri for Scientific Analysis Group, DRDO.** Text and Speech corpora has been developed as per the given specifications for three Indian languages namely Hindi, Bengali and Manipuri. The corpus is the basic requirement for building Language and Speech systems. It will lead to the development of Language Identification, Speech Recognition and Speaker Identification systems useful for defence applications.

The scope includes different sets of speech recorded and annotated at phoneme level, in multiple environments like quiet, normal, and noisy office and in moving conditions by a number of male and female speakers. A textual dictionary of all the words covered is also being developed, having the fields' words in respective scripts and words in Roman coding.

- **Hindi Speech Corpus for European Language Distribution Agency (ELDA), France.** The scope of the project included development of Annotated Speech Corpora for Hindi by 2000 persons. Recording of Speech corpora in various environments like home/ office, moving vehicle, public place, street etc. by speakers having Hindi as the first language using GSM network was to be done. The Speech Corpora would cover Hindi speech prompts spoken by people from different dialectal regions and age groups. The project has been successfully delivered.
- **Annotated Speech Corpora for Three East Indian Languages (Bengali, Assamese, Manipuri).** This was completed in the year. A semi-automatic speech signal annotation software and a complete monograph on speech corpora development in Indian language was developed.

Indian Language Digital Library

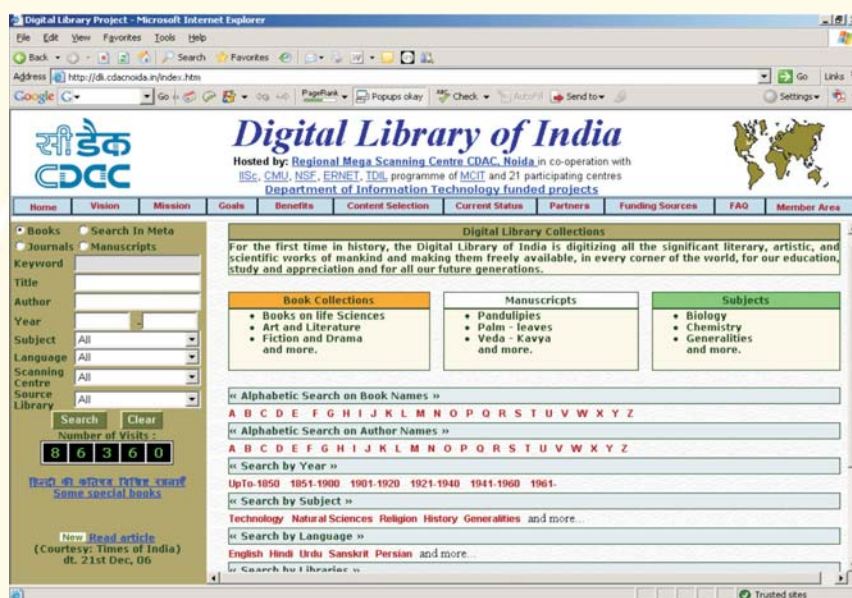
Mega Centre for Digital Library

C-DAC has been nominated as one of the Mega Centres for Digital Library for catering to the digitization needs of Libraries in Delhi and other northern States. The objective of this project is to digitize 14 Million Pages of rare books, manuscripts, magazines etc. for putting on the web. For this work C-DAC has collaborated with various leading institutes and libraries such as ICCR, IARI, Gurukul Kangri Vishwavidyalaya, Hardwar, BITS Pilani, Association of Indian Universities etc. apart from work already done at Nagari Pracharini Sabha Varanasi, Kumaun University Nainital, GB Pant University, Pantnagar. As the data in physical form is being digitized, the tools and utilities required for its optimal use are being developed that would help in managing, searching and maintaining the digitized information better.

The first version of tools such as "Cross Language Information Retrieval", Text Summarization, Multilingual Crawler, Digital Library Management tools have been developed.

Book digitization work is in progress at the following libraries:

- Central Library, Visva-Bharati, Santiniketan
- State Central Library, Kolkata
- Uttarpara Jaykrishna Public Library, Hooghly
- North Bengal State Library, Cooch Behar
- TRA Library, Jorhat, Assam
- Ramakrishna Mission Institute of Culture, Kolkata
- Hooghly Mohsin College, Hooghly
- West Bengal Legislative Assembly, Kolkata
- The Asiatic Society, Kolkata
- Bureau of Applied Economics and Statistics, Govt. of West Bengal
- Also at the office of the C-DAC, Kolkata



More than 5.6 Million pages from 14 thousand books have been digitized and are ready for hosting on the Internet.

Digital Library Core Technologies for Bengali and Assamese

The following core technologies have been developed under this activity:

- OCR with workflow
- Multilingual and multi-modal authoring tools
- Automatic search indexing tools
- Folk songs search and retrieval tools. Two hundred and fifty Bangla folk songs ('Baul Songs') have been recorded on both audio and video. Meta data of these songs have also been prepared

Vigyan Prasar Digital Library

The scope of the project was to build a web portal that will help to keep track of Vigyan Prasar's publications. The first phase of the project included the development of the web portal, which comprised of a detailed category wise listing of their different areas of work. The design of the web portal has been worked meticulously upon and has been widely appreciated. Also, a facility for viewing the site in Hindi has been incorporated. The site can be viewed at <http://www.vigyanprasar.gov.in/>

In the second phase of the project a Digital Library comprising of various publications of Vigyan Prasar was needed to be developed. There are separate sections for English, Hindi and other regional language books published by them for effortless viewing. Various posters have been incorporated separately here. For controlling the functioning of the Digital Library a separate administrator section has also been developed. Search feature has been introduced within digital library where by search can be made based on title of the book or a facility for content search is provided whereby it looks in the contents of the book and produces results accordingly, this feature is only available for English books. The Digital Library can be viewed at <http://www.vigyanprasar.gov.in/digilib/>

Overall, in this project for the purpose of Digital Library around 150 books have been scanned out of which some are colored, around 200 images and 5 posters have been scanned.

National Rollout of Language CDs

CDs containing Software Tools and Fonts for Assamese, Malayalam, Marathi, Oriya, Kannada, Punjabi and Urdu languages have been released at a function organized at DIT, Delhi in the presence of Thiru Dayanidhi Maran, Hon. Union Minister of Communications and IT on January 24, 2007. A total of 3.5-lakh language CDs have been distributed to the registered users through the postal department.



European Commission Interactions

C-DAC is spearheading the following initiatives under projects funded by the European Commission:

- **Indian Networks Cooperation in Information Society Technology with Europe (INCITE).** Its objective is to promote participation of Indian IT constituency into the ICT community Framework Programme of European Commission.
- **Indiamentor.** Its objective is to identify and facilitate the Indian ICT organizations, which are working on specific domain areas, defined in the FP7 of European Commission.

Indian Language Fonts

C-DAC is working towards development of more than 1000 highly aesthetic Open Type fonts for all the 22 scheduled Indian languages and development of "Sakal Bharati", an Open Type font with multiple languages especially for e-governance type of applications.

Other Initiatives

Few other initiatives in the area of multilingual computing and allied areas include the following:

- **DVB subtitling** - Working in collaboration with Doordarshan to develop a solution for Subtitling on the MPEG –II based DVB systems used in DTH transmission and has successfully tested the same at Doordarshan, Mumbai. This will allow even the viewers, the flexibility to select the language of their choice through the Set-top-box.
- **BIIDS system** - Bilingual Integrated Information Display System specially developed for Parliament houses to display relevant information like speaker's name, logo of the house, agenda of the session, etc. through the software during the sessions.

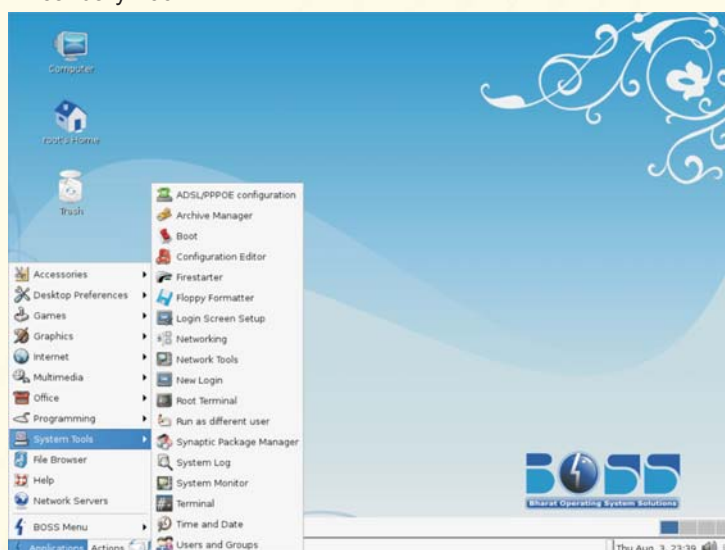
- Portable Teleprompter - is an ideal tool for anchor-based programs and outdoor shoots. Weighing only 2.5 kgs offers users a 9" prompter which supports all Indian languages and can be interfaced with any newsroom system. Installed at ANI (BBC) News Centre.
- Linux Operating system, graphics library and JVM have been ported on ARM based board for various handheld applications.
- Localization Framework based solutions were successfully designed and deployed for Banking and Finance segments. Localization Framework supports for various activities such as Indian Language Passbook Printing, report generation, database support and statement printing. Clientele for localization solutions includes UCO Bank, Kolkata for bilingualization of statement and reports, implementation of iPlugin for enabling SIFY email in Indian languages, CIDCO - GIST Ora Tools implementation for report generation, Rajasthan Police – implementation of ISM and nTrans used in application developed by ROLTA for filing FIR's and data base creation, MANITRON - GIST Solution for application development, Motorola - Solution for mobile handsets.
- Corporate orders received from Eastern Railway, Kolkatta, Geological Survey of India, Southern Command, Pune, Information Kerala Mission, Kerala, ECIL - ISM used for Agmark Project, IT@School, Kerala, MSEB, Maharashtra, Government of Orissa, SEWA, Registry Department (PEARL), Kerala - ISM integration with the application.

Software Technologies (Including OSS/ Linux)

Open Source Software Initiatives

Bharat Operating System Solution (BOSS) Linux

The National Resource Centre for Free and Open Source Software (NRCFOSS) at C-DAC, Chennai has developed an Indian version of Linux named "BOSS Linux". It was released by the Hon'ble Union Minister of Communications and Information Technology during ELITEX 2007 at Delhi in January 2007.



BOSS GNU/ Linux is a localized Indian distribution of GNU/ Linux. This Linux distribution (distro) is based on Debian Linux and is targeted at the government user initially. The ultimate objective of creating BOSS Linux is to enable the people of India, most of who are not English-literate, to be exposed to Free and Open Source Software (FOSS) and GNU/ Linux. BOSS Linux desktop edition ver 1.0 was released during Elitex 2007. The currently available version is 2.0 beta. C-DAC submitted a proposal for establishing BOSS Linux Support Centres across the country and the same has been approved by DIT, MCIT, Government of India.

Open Source e-Governance Framework

The eGov Framework developed using open source technologies based on Service Oriented Architecture (SOA) will assist in Service enabling legacy applications of the departments for interoperability and allow for development of newer SOA based applications. The Framework will streamline and ease the intercommunications between various departments. The Framework will provide various access methods and support for service delivery through multiple delivery channels and multiple front end devices for accessing information through the convergence of various communication technologies viz. web based clients, mobile computing services (through a mobile phone or similar hand held devices). Service enabling Birth and Death Registration module of the Health Department has been completed.

Flossworld

Flossworld is a European Union-funded project. It is a 2-year project that started in the year 2005 involving 17 partners from 12 countries around the world. The project promotes international collaboration between the EU and third world countries, conducting research and developing policy related to Free/ Libre/ Open Source Software at global level for the first time, in Argentina, Brazil, Bulgaria, China, Croatia, India, Malaysia and South Africa. Led by the Maastricht Economic Research Institute on Innovation and Technology (MERIT) at the University of Maastricht in the Netherlands, the project brings together major European research institutes and leading public research institutes in the target countries.

janabhaaratii

The objective of this project is to enable wide use of Indian Language Computing through Free/ Open Source systems and applications localised in Indian Languages.

The project aims at inviting, building and supporting community initiative to produce and disseminate free/ open source software systems, applications and contents to help proliferate widespread use of Information Technology in our society.

janabhaaratii is funded by the Technology Development for Indian Languages, Ministry of Communication and Information Technology, Government of India.

indicbhaaratii Portal

The portal is meant for a collaboration effort for Indian Language Computing, initially covering six languages but eventually providing for all Indian Languages. The initial six languages are – Hindi, Marathi, Bengali, Gujarati, Punjabi, and Tamil. This will also be a resource site for FOSS resources developed by the community of developers and available to the community of users. This will be a pioneering effort to encourage entrepreneurs and developers to cooperate and evolve a viable economic model for the use of Free / Open Source software. However, the portal in itself will only be a facilitator of this interaction and will not get involved into financial transactions.

Moodle Localization

Moodle is an Open Source Learning Management System (LMS) being used by C-DAC for its e-learning activities. It is a simple, but powerful LMS used by many other institutions in India and abroad. As an attempt to extend e-learning to reach the non-English knowing community, C-DAC is localizing this application into various Indian languages. Currently, the system has been localized for Hindi.

Software Engineering

Software Accessibility

Software Accessibility refers to the tools and technologies, which allow or help people with disabilities to use computer software tools effectively. Following are some of the activities related to accessibility that is being pursued at C-DAC:

- Exploration of various tools related to Software Accessibility, such as Screen Readers, Mind Mapping Software, Captioning Software, Predictive Text Software, etc.
- Exploration of Accessibility Frameworks and API's (e.g., AT-SPI, GAIL, JAVA Accessibility, etc.)
- Speech Interface for Open Source Software

The aim of this project is to create a Speech Interface for common software on the Linux platform. The user will be able to give commands to the applications through a Speech Interface. The speech commands will be communicated to the application using the accessibility interface.

CMU's Sphinx4 Speech Recognition Engine Framework is being used for this work.

The initial experiment was to speech enable Pine e-mail Client. The experiment required modifications in the Pine code; a proof of concept system is available. We then moved to speech enabling Mozilla Firefox. No modification was made to the Mozilla Firefox code. Instead Accessibility API's were used to access Mozilla Firefox widget hierarchy and generate events on them. This provides a generic mechanism, which can be used for a variety of software, with no modification to its source code.

Control Flow Framework for Evolving Systems (CFFES)

CFFES deals with multiple rules with specific temporal validities that are overlapping. If the existing business rules are valid then the risk of changing the existing operational system should be avoided. This will reduce the possibility of introducing errors due to the changes (ripple effect). Hence the impact of change to the already operational system can practically non-exist and the maintenance costs due to evolution in business rules can reduce by considerable extent. The modularisation framework works at the abstraction level of functional components hence can be applied to systems irrespective of the design methodology followed, e.g. object-oriented or structured.

Quality Metrics for e-Learning Tools

Under the project, the scope of the quality indicators with respect to evaluation of e-Learning tools has been identified and experiments based on these indicators are being carried out. Training teachers in e-Learning through one-week training programs on e-Learning tools, content development and standards is one of the project objectives. C-DAC has successfully conducted three teachers' training programmes till March 2007 on e-Learning.

The eSikshak software has been offered to premier institutes like National Institute of Agriculture Extension Management (MANAGE), Hyderabad and Indian Law Institute, New Delhi for delivering of courses offered by their respective centres.

Incremental Localization Tool

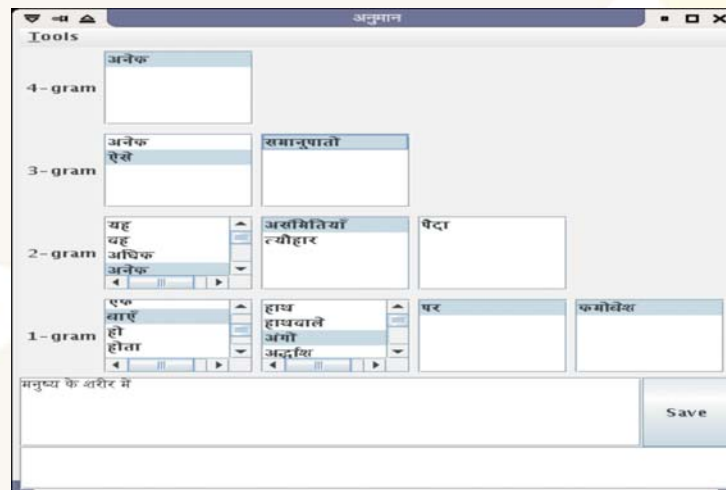
Based on experience generated in localization and interaction with the localization community, C-DAC is building tools to simplify the localization process so that more people can contribute to the localization efforts. One of the areas we are investigating is Incremental Localization. This is concerned with adapting the localization efforts carried out for one version of the software to subsequent versions.

Dependable Agents based Self Aware Environment (DAgSAE)

In the second phase, the C-DAC Mobile Agent Framework (CMAF) has been enhanced to address the users of fault tolerance of agents. This is a first step towards achieving self-healing property of agents in autonomic systems. The newly added feature to the framework has been tested on an enterprise network for a system monitoring application.

Anumaan (A Non-linear Predictive Text Entry System)

Anumaan is a perspective based Predictive Text Entry system that facilitates text entry by anticipating words based on prior experience/ training corpus. This helps enhance the text input speed for those who do not have high keyboard speed and reduces errors due to data entry.



Vidwan

This is an Expert System framework that allows creation of rule-based expert systems by encoding expert's knowledge as a set of rules (each with uncertainty), and knowledge inferencing done using in-built backward chaining inference engine. The framework is now being web-enabled.

Case Based Reasoning

Case based reasoning is inspired by human tendency to solve problems based on past experience and is a very recent activity in C-DAC. C-DAC is investigating the suitability of this technique to solve the select problems in the agriculture such as pest control, crop selection, etc.



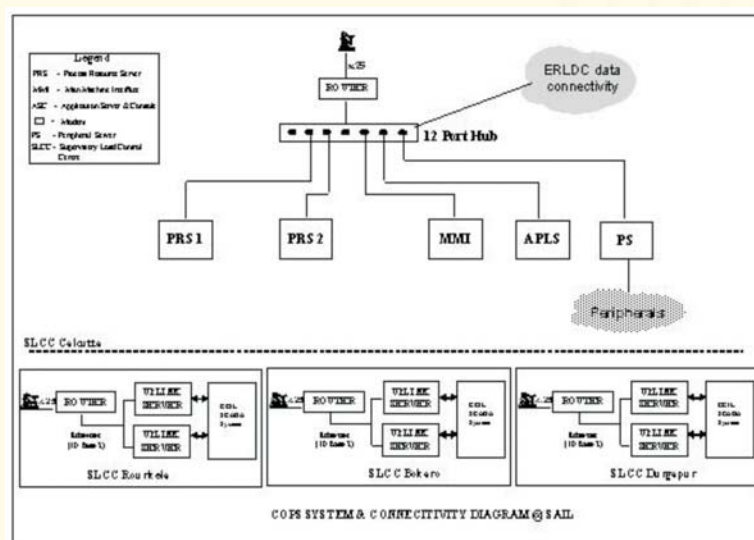
Software for e-Governance Applications

State Council of Educational Research and Training (SCERT), Government of Kerala

The activities of the various departments of SCERT including the Academic and Training Department, Establishments, Accounts, and Budgeting are covered. Workflow automation software allows for integration of the different departments, file-tracking software is provided for electronic transfer of files for reviewing, commenting and approving by various officers. eForms for TA Bill processing, Online Indent and processing for purchase department are provided. This is a web-based solution based on J2EE framework with MySQL in the backend, various MIS and operational reports are generated using the Jasper Open source reporting tool. Role based authentication is used for authenticating the users of the various departments.

C-DAC's Open Process Solutions (COPS) for SAIL

COPS having the features of acquisition, presentation and storage of data from different data sources were upgraded for SAIL. The new version COPS with additional features on data presentation (virtualisation) long term archival and remote diagnostics tools were released. An application model for maximum demand and small scale schedule value processing was also added. The data communication is over NIC net (using VSAT) from all the plants of SAIL (Durgapur, Rourkela and Bokaro) and Supervisory Load Control Centre (SLCC), Kolkata. The project was successfully completed.



IOSN South Asia Node

C-DAC bagged a contract from UNDP-APDIP/ IOSN for setting up the South Asian regional centre of IOSN at its Chennai centre. This agreement came into effect from 01-March-2006 and expires on 30-June-2007. IOSN is an initiative of UNDP-APDIP and supported by the International Development Research Centre of Canada. IOSN promotes the adoption of Free/ Open Source Software (FOSS), Open content and Open standards for sustainable human development in the Asia Pacific region. It is a network with a regional centre in Bangkok and three centres of excellence – IOSN Asean+3, IOSN PI, IOSN South Asia. The South Asia node will assist in the creation of white papers, organizing/ participating in events related to FOSS, conduct training programmes and encourage cross regional dissemination of information related to FOSS.

eSenani Web Solution

eSenani Web Solution is a web application designed and developed by C-DAC for the welfare of Ex-servicemen, Civil Beneficiaries, Widows and their families. The Solution is a web-based Application developed for online registration and data operations, which can be utilized by the Department of Defence Welfare of any State. It covers all the areas of defence related departments i.e. canteen, beneficiaries, financial grants, service related queries like pension, funds, awards, jobs, e-mailing, etc.

Mulyaankan

Mulyaankan is a Data Mining application aimed at discrepancy detection in the valuation of import items, developed for the Department of Valuation.

Nearly a million imports arrive into India every year, spanning a variety of items. Government notifications issued from time to time, dictate the amount of duty payable on these items. The duty rate may vary from 0 % to 100% or even more for selected items.



Imports are recorded at the port of arrival through a number of documents such as bill of entry, import manifest, etc. Most of these are entered into a computerized database system and hence are available for analysis.

Imports and exports are often grounds for a number of malpractices. For example, by quoting a lower rate for a purchase of an item, the duty payable can be reduced. Automated assistance to identify cases where such malpractices are likely to have occurred would be useful for Directorate of Valuation. Another scenario would be to make the valuation officials across the various customs houses aware of the current price-range for important and sensitive commodities from time to time. This would enable them to check declared prices at the point of valuation itself.

The Mulyaankan system was conceived as a toolkit that would aid valuation officials to track items of interest across custom houses with respect to domain specific parameters, perform offline analysis of imports for detecting outliers.

Core Banking Solutions at Kerala State Cooperative Bank

This was a consultancy project for the computerization of the Kerala State Co-operative Bank (KSCB), through core banking solution, interconnecting 20 of its branches and 3 regional offices, to the head office at Thiruvananthapuram. This project was in continuation of an earlier work, during which C-DAC suggested solutions, prepared the high level design, and the RFP (Request for proposals).

Software used is the popular product FLEXCUBE from iFlex, which has been customized by M/s iFlex, and another vendor M/s Nest has supplied hardware. In this project, C-DAC's role was that of a consultant, monitoring and certifying the implementation, onsite support during initial run, and implementation of add-on features and integration with the Data Centre (State Information Infrastructure).

Integrated Transaction Accounting System (ITAS) – Northern Railways

The system with a capability to handle all accounting functionalities of Indian Railways along with Provident Fund deployed at the Northern Railways, North Western Railways and North Central Railways and their Divisions is being maintained by C-DAC. Various additional functionalities like Account Current Merging and RAR merging at the Head Quarter level has been provided. Currently all the locations of Northern Railways and North Western Railway are under maintenance with C-DAC.

An enhanced version of iTAS for the construction department of Northern Railways has been developed and is being implemented at the Construction Head Quarters at Kashmere gate, Delhi.

Personnel Management Information System (PMIS) – Northern Railways

It is a web-based application, meeting the requirements of the Personnel Department of Indian Railways, manages the career event of employees starting from induction to superannuation. The major modules includes Service Record, Promotion, Transfer, Training, Court Cases, D&AR, Dak and File, Staff Grievances, Industrial Relations, Welfare, Policy etc. The project has been developed and implemented at Northern Railways Headquarters, Delhi Division, DLW/ Varanasi and is under maintenance.

Delhi Police Inventory Management System (DPIMS) – Delhi Police

DPIMS is a web-based system. Information would be made available on real time basis at all the levels across Delhi Police. Automatic projection of yearly demand of various items and requirement of various items at each District/ Unit is automatically calculated. There would be transparency and accuracy in the process as the data saved at one level can be shared at all the required levels without any delay and tampering of data. C-DAC was involved in the setting of the data centre at the Provisions and Logistics unit of the Delhi Police.

Security Management Information System (SMIS) – Northern Railways

It is an on-line management information system developed for the Railways Protection Force and has been successfully implemented at Northern Railways. This system keeps track of the arms and ammunition, stores, establishment matter of employee, crime records and miscellaneous crimes details. After successful running of the system in Northern Railways, the same has been deployed in Central, Southern, West Central and South Western Railways. Currently a browser based solution for SMIS is being conceived through third party software.

Material Management Information System (MMIS) for North Western Railway

MMIS for North Western Railways is under development and will be a Comprehensive Enterprise wide Material Management Application for the Railways. It is supposed to have five functional modules: Purchase will cover demand registration, purchase proposal, vendor registration, tendering/ offer entry, PO and indent related activities. Depot will include functionalities of yard, receiving section, ward and local purchases. Stores accounts will cover the functionalities of bill passing, suspense accounts, stores monthly summary, imported, fuel accounting and PL unit sales and auction will cover the functionalities of SS-11, joint inspection, bid sheet, delivery order, sales accounts and Uniform will cover the functionalities of demand registration, BOM, PD rate fixation, labour, on-cost and Fabrication Order. The software would provide a Web Based MIS for resource consuming functions like knowing Demand Status, Stock position (Depot wise/ PL wise), Demand Registration, etc.

Stamp and Registration Software

C-DAC's Stamp and Registration software facilitates maximum citizen interface and caters to the needs of the Department of Registration and Stamps. A replicable and scalable application suite, the software can be customized to meet specified requirements.

KAVERI - The Registration Software for the Department of Registration, Government of Karnataka, has been successfully deployed in all the Sub Registrar/ District Registrar Offices in Karnataka. Work for providing encumbrance search over the Internet and the facility for providing anywhere registration is now being initiated. Centralized Management Information System [MIS] is now being designed over the KAVERI Suite of applications in a networked environment where all the SR/ DR offices will be connected to the State Registrar's office.

GAURI - The Development of Registration Software for the Department of Registration, Government of Goa has been completed and the software is being piloted at a Sub Registrar's office.

SARITA - The Registration Software for the Department of Registration, Government of Maharashtra has now been handed over to the client after the successful design, development, deployment and maintenance by C-DAC.

Public Works Department, Goa

The design and development of web-based software related to all the functional wings of the Department like Establishment, Projects, Finance and Stores have been completed and are deployed at select offices for pilot usage. A GIS Based Road Information System has also been designed. A comprehensive website containing static as well as dynamic sections has been developed and released for hosting. The software for the department has been developed with open source technologies.

An enterprise level Wide Area Network for the Department has been designed by C-DAC and is now being taken up by the department for implementation

Online Management, Monitoring and Accounting System for Pradhan Mantri Gram Sadak Yojana

Pradhan Mantri Gram Sadak Yojana (PMGSY) is a nationwide rural road programme managed by the National Rural Roads Development Agency (NRRDA), an Agency of the Ministry of Rural Development (MoRD), Government of India. In order to effectively monitor the entire programme and bring about greater efficiency, accountability and transparency in implementation, a web based application software, the Online Management, Monitoring, and Accounting System (OMMAS) has been developed by C-DAC. The web site is available through the PMGSY website www.pmgsyonline.nic.in.

System Study for Automation of Command Headquarters

The scope of the project covered the thorough study of all the five Command Headquarters situated in Pune, Kolkata, Chandigarh, Udhampur and Lucknow, and documentation of the same using Rational Unified Process (RUP) standards in the form of

- Vision Document substantiated by Business Use Case Model and Business Object Model
- Supplementary Specifications
- Operational Concept Description Document (OCD)
- Stakeholder and User Requirement Specifications Document (URS)
- System-Subsystem Document (SSS)
- Interface Requirement Specifications (IRS)
- Use Case Model
- Activity and Sequence Diagram
- Secure Network Architecture
- Disaster Recovery Plan and
- Security Policy

was provided by C-DAC.

Scope also included drafting the RFP for subsequent phase of the project, recommendation on integration of existing software at Army Headquarters and proposed software at Command Headquarters and the Function Point Analysis information.

The project has been successfully delivered to the client.

Madhya Pradesh Road Development Corporation

C-DAC has been appointed as the Technical Solution Provider (TSP) for the Computerization of Madhya Pradesh Road Development Corporation. C-DAC is in the process of developing a web-based software like Asset Inventory Management System, Works and Contracts Management System, Budget and Accounts Management System, MIS for Project execution and monitoring.

National Service Delivery Gateway (NSDG)

The NSDG is one of the 26 Mission Mode Projects under the National e-Governance Plan (NEGP) of the Government of India (Gol). The NSDG will facilitate standards-based interoperability and integration services to the existing and new e-governance applications. As part of its implementation strategy for the NSDG, the DIT has entrusted the responsibility for implementation of NSDG to C-DAC. C-DAC shall have the prime role of the Gateway Service Provider (GSP), and shall be responsible for the development of the NSDG.

IT Implementation of Toddy Board Activities

The Kerala State Toddy Workers Welfare Fund Board (KTWWFB) is the first Welfare Fund Scheme in Kerala, introduced for the welfare of workmen in toddy tapping and distribution sector. This is the biggest welfare board in Kerala State with about 52,000 members.

The computerization of the KTWWFB envisages the usage of Information Technology for enhancing the efficiency of the functioning of the Board. The software system developed by C-DAC aims at creating an efficient system to replace the existing manual system. Administering and monitoring of day-to-day activities of the Board can be improved by using the networked system, which guarantees easy data transfer between head office and district offices

The prime beneficiaries of the computerization activity are the members of the fund namely the workers, which include the toddy tappers and the workers in the toddy shop. The highlights of the project include better financial management of the Board, better service delivery to the members of the Board, and effective management of the Board.

The software in the head office in Thiruvananthapuram and the 13 district offices has been developed fully in free and open software. The head office system and the district office system communicate with each other through dial up connectivity. The user interface and the data stored are all in Malayalam. This is one of the first ventures in free software for the e-governance implementation in Kerala state where Malayalam is used for the entire Enterprise solution.

IT Implementation of Tailor Board Activities

The Kerala Tailoring Workers Welfare Fund Board is a statutory organisation set up for providing various welfare measures to tailoring workers and their family. It has its Head Quarters at Thiruvananthapuram and has 8 district level offices for managing the Fund Schemes of 14 districts. The Board has more than 3 lakh members.

The system aims at creating an efficient service delivery mechanism for the tailoring workers, who are members of the Board. Communication between the Head office and the district offices is through dial up, which can be enhanced to IP based wireless based one at any point of time.

The system covers both the functional activities of the Board and Establishment.

Kerala State Wide Area Network

Government of Kerala has set up a resilient State Information Backbone connecting Thiruvananthapuram, Kochi and Kozhikode, which has been designed and implemented by C-DAC. The design objective of the backbone network (named as State Information Infrastructure) has a state-of-the art network, which is highly robust, resilient, scalable and highly available, which provides equal access to all users, irrespective of their physical location. Kerala State Wide Area Network is the extension of this backbone to all the 14 districts and 152 blocks of the State. The last mile connectivity to the various Government offices from the network centers at the blocks and districts had also been envisaged. C-DAC was entrusted with the design, consultancy, project management, testing and acceptance and monitoring of the network.

The KSWAN backbone is complete in all aspects and is operational for the last one year. The distribution layer is partly complete upto the district level, which is mainly being used for video conferencing. More than 50 e-Governance applications are currently making use of the infrastructure. The complete network will be functional by December 2007.

Real-Time IT Operations Management and SLA Monitoring System for E-Governance Networks

With the implementation of the State Wide Area Networks in different states in India, Government will be depending on their IT and communications infrastructure to deliver many citizen centric services. However, managing these infrastructure - effectively, efficiently and in real time - poses increasing challenges as IT environments become larger, more heterogeneous and distributed. The objective is to develop a software solution that supports a comprehensive approach to consolidated operations management and SLA monitoring, providing a single Pane of Glass view in the form of real time dashboards, helping in rapid diagnosis and resolution of infrastructure problems.

The objective is to develop a flexible cost effective Monitoring Tool that can monitor the availability and performance of a large number of heterogeneous network components with minimum intervention from the part of network administrator and thereby monitor the SLA for customers and providers. The system can also perform trend analysis and capacity planning. The system will also alert the performance breach through e-mail or SMS and has to be a cost effective solution that can be easily configured by the network administrator.

The system will support an automated process that entails discovering the physical and logical components of the IT infrastructure, determining how they are interconnected or interrelated, and generating a "topology" data store. The tool shall be capable of consolidating events across multiple IT infrastructure for broad coverage and awareness of potentially service-affecting events in the network and relate two or more pieces of data to each other, typically to accelerate or enhance problem resolution, i.e. apply multiple correlation methods- to the events being generated through event collection. The tool shall measure the service quality and generate SLA scorecards for the IT services offered through the networks.

ICT based Program for Rehabilitation Officials and Specialist Teachers

The objective of the project is to provide a scalable pilot infrastructure facility for imparting distance training for the trainers in the field of special education. This is a VSAT based solution by using the bandwidth of EDUSAT. The teaching end facility as well as the facilities at seven schools of special education will be set up and managed as part of the project.

In this project, KVM School of Special Education, Chertala, Kerala has been identified as the teaching end and the existing Hub location at Gorky Bhavan, Thiruvananthapuram has been identified as the Uplink station. Seven special schools have also been identified as virtual classrooms in the pilot phase with Satellite Interactive Terminal (SIT). The connectivity between the Teaching end and the Uplinking station has been established over the State Information Backbone.

Enhancement of Akshaya Network Malappuram

Project Akshaya is an endeavour to 'Bridge the Digital Divide' and propel Kerala as India's foremost knowledge society. Under this project, one person in every family in Kerala will be familiarized with the basic use of computers and empowered to access innumerable services that Information and Communication Technology offers. It also ensures affordable and easy access to computing resources.

The project involves setting up of around 5000 multi-purpose community technology centres called Akshaya e- kendras across Kerala. Run by private entrepreneurs, each e-kendra, set up within 2-3 kilometres of every household, will cater to the requirements of around 1000-3000 families and will make available the power of networking and connectivity to common man. Akshaya is a social and economic catalyst focusing on various facets of e-learning, e-transaction, e-governance, information and communication.

The pilot Akshaya project implemented in Malappuram district in Kerala has about 500 Akshaya centres. All these centres, spread across 3500 Sq km, have been connected to Internet over wireless. The backbone network is also over wireless, making Malappuram the first district to be connected completely over wireless. The Akshaya wireless network consists of a Network Operating Centre located at KINFRA park, Kakkanchery, a wireless backbone with 29 Points of Presence (POPs), and the last mile wireless coverage to Akshaya centers from the base stations collocated at these POPs. Various wireless technologies from Airspan, WiLAN and RADWIN have been used in the Akshaya network, which is running successfully from 2004 onwards.

C-DAC has been providing Technical consultancy for the Akshaya project in Malappuram since inception. On the connectivity part, C-DAC was entrusted by Government of Kerala on requirement analysis, RFP preparation for Connectivity, Service provider selection, Project management, network testing and acceptance and network performance monitoring.

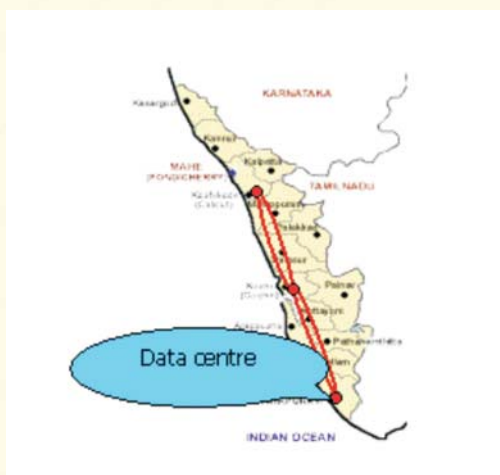
This project involves providing technical consultancy for Akshaya network enhancement and providing turnkey solution for strengthening and enhancement of network performance.

Democratic Information Infrastructure for Administration through Multi-Objective Network Depository (DIAMOND)

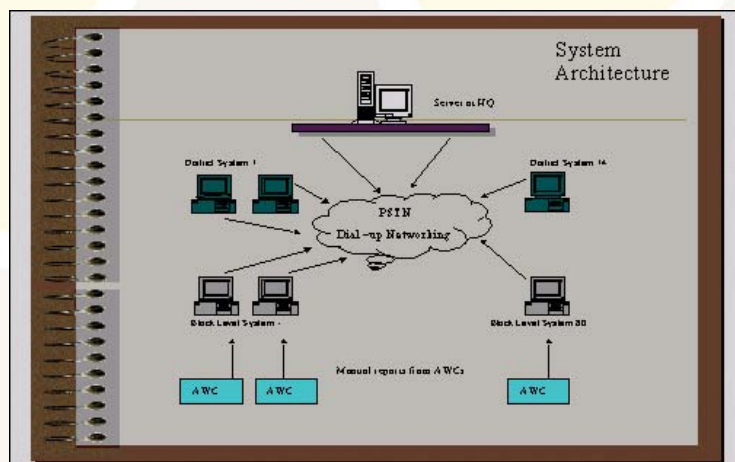
The State Information Infrastructure for Kerala 'DIAMOND' consists of two facilities: The State E-Governance Data Centre and State Information backbone. The State E-Governance Data centre is located in Thiruvananthapuram. The State Information backbone extends from Thiruvananthapuram to Kozhikode, with network aggregation centres at Thiruvananthapuram, Kochi and Kozhikode.

Major Features

- 5000 sq ft Data Centre, first of this kind in India designed and implemented.
- Highly resilient State Information Backbone designed and implemented between Thiruvananthapuram and Kozhikode.



- Developed a Rapid Application Development tool.
- More than 50 e-Governance applications currently running from the Data Centre.
- More than 60% utilization within two years of implementation.



MIS for ICDS

The ICDS Scheme seeks to deliver a package of basic services for children, mothers, pregnant women and adolescent girls. The objective of this project was to develop an Integrated Management Information System, which consists essentially of three elements viz. Work Reporting, Monitoring and Evaluation and Feedback for decision-making. The System is called SIMCOM.

This is one of the early E-Governance initiatives using free software platform. The system is developed on Linux platform. The RDBMS used is the Postgre SQL Object DBMS. The development environment included Qt, Java and the report generation tool namely Kugar.

Employee Information System for Municipal Corporation of Delhi

The Employee Information System (EIS) is an excellent J2EE architecture based HR management tool based on the Government Establishment Manual and provides services like recruitment, monitoring training and man-power planning, maintaining service records, roster, on-line transfer process, employee promotional activities and maintaining seniority of various categories of employees, payroll, loan and advances, accommodation etc. The entire system is workflow enabled so that basic architecture and functioning of MCD remains the same, leading to a paperless office. An optimised search engine has been developed to track the related information. This product has various MIS reports that help in monitoring day-to-day work of staff. The EIS system streamlines various functions of the Personal Department and Accounts of Municipal Corporation of Delhi. The core areas covered are system security, data transfer, defect tracking, back-up, recovery, record keeping, automation of various departments and several management tools to help the management at the time of decision making.



This product has been deployed in data-centric architecture and is being accessed at 20 MCD geographically distributed locations and currently system is in the phase of data management and will manage 1.47 lakh serving regular as well as daily waged employees.

Online Activity Registration by Citizen

This application was developed for the MCD. The scope of system was to register the citizens who are running their commercial activity, like small shop/ retail shop/ professional activity/ other activity, and issue of registration certificate for such candidates. The nature of application was true 24x7. The system was deployed in data-centric architecture. Around 3 lakh online activities have been registered through the system.

Sangam - An Intranet Application for Central Water Commission

This product was developed by C-DAC to offer the aspect of automated office management, which can manage the daily routine work of the CWC. It comprises 9 modules namely Personnel Information System, Finance Management, Budget, Intranet Information Highway, Parliament Query, Correspondence management, Office Administration, Payroll, Library Management. This product is being accessed through the wide area network of CWC. Currently the product is under maintenance phase at CWC headquarters and will be deployed at various parts of India through the dedicated WAN of CWC.

Maintenance of Subscriber Billing and Payment Accounting of Calcutta Telephones

The various activities carried out under the project are as follows:

- New Module for Broadband Billing
- Various perfective jobs related to Billing System
- Annual Maintenance (Corrective) of the Billing System

Software for e-Learning Solutions

Marathi Tutor

Marathi Tutor is a web-based constructive learning environment for teaching spoken or conversational Marathi. English is used as a supporting language of instruction. The system aims to enable the user to read/ understand newspapers, converse at public places (restricted domain), etc in Marathi. A number of pedagogical ideas are incorporated in the system keeping in mind challenges of retaining motivation, attention and focus for a typical e-learner.

The system is currently usable; it is being improved in many dimensions. There are plans to enrich it further with additional pedagogy ideas for effective instruction. Instruction module can be extended to give more intuitive feedback to the student after every exam, which will help him identify his weak areas in the course.

Sandesh - An Automatic Email Response System

SANDESH is an automatic email response system, which is useful in an online learning environment. The system acts as a middleman between the faculty and the students. All the queries posed by the students to the faculty is intercepted by Sandesh, which checks its repository to see if the same or similar query has been asked earlier and if a response to it is already available. In such cases, Sandesh forwards the corresponding response to the student; else it forwards the mail to the faculty. Sandesh also intercepts the response from the faculty so that it can update its repository.

Sandesh is not restricted to the e-learning environment; it can also be useful for scenarios like help desk, customer support centre, enquiry services, etc.

Veda – An Online Testing and Question Banking System

Testing and evaluation are amongst the most essential components of a learning process. With the advent of computers and e-learning, a huge scope for improvement in these has developed. Computers provide a means of handling, storing, manipulating and analysing large data sets. Veda aims at using these capabilities for better evaluation and testing. The system provides functionality of test conduction and evaluation of objective type questions along with extensive report generation.

The system supports conduction of a variety of tests each of which can be configured on the basis of evaluation criterion, order of quiz appearance, students eligible for it, etc. The quizzes themselves could have an evaluation criterion, which is made up of parameters like marks allotted to questions and passing marks of the quizzes.

To curb use of unfair methods the system provides question scrambling and option scrambling. In case of a system failure due to external factors an automatic recovery is invoked when the system is restarted and lets students continue the test from the state they left.

The next increment aims at integrating the teacher side functionalities with the system such as test preparation and question banking, and generating intelligent inferences from the report.

Subjective Evaluation Framework

“Subjective Evaluation Framework” is a web-based system to manage examinations consisting of descriptive or subjective type questions. It is a useful tool for educational organizations conducting exams that consist of descriptive type questions or a mix of descriptive and objective questions.

The system caters to three users viz. faculty, student and examiner. The faculty can set subject-topic relationship, maintain question and create question paper pattern (consisting of sections, subsections, etc) along with appropriate marks distribution. Faculty can also create a question paper for a subject using a particular paper pattern and questions from the question bank, assign students to a specific exam, etc. Student can appear for the exam online entering the answers in a textbox with optional diagram attachment. The examiners also evaluate the answer sheet of various students online, using various evaluation strategies like question-wise (for each student) and student-wise (for each question).

Virtual Classroom

Virtual Classroom is a classroom simulated via Internet. It provides a convenient learning environment for distance learners similar to the one provided in traditional face-to-face classroom. It is essentially a sharing of the presentation data (slide transitions, resources, etc) between the presenter and participants. The contents presented by the presenter are broadcast to all the participants. The system also facilitates the participants to communicate with the presenter and other participants. It can be used for conducting live lectures online, webinars, online discussions, etc.

Users can use Virtual Classroom in two modes – as a presenter, or as a participant.

The presenter can:

- Start a session
- Add/ Remove participants from the session
- Create Agenda
- Upload Resources
- Use presentation slides and whiteboard to broadcast information to participants
- Create polls and view response to a poll

A participant can:

- Connect to the session through the LAN/ Internet and view the slides transition/ whiteboard
- Download the resources
- Use the hands-up facility to ask any queries to the presenter
- Respond to a poll

The users in a session can communicate among themselves using one-to-one and/ or group chat.

Currently, work is in progress towards more enhanced features, like:

- Live Audio/ Video
- Recording sessions
- Break-out sessions, etc.

Pedagogy-oriented Content Markup Language (PCML)

PCML is a markup language for creating content. It allows a teacher to create content, independent of any Content Management System (CMS). PCML defines a set of tags for content, based on the pedagogic role of a particular part of content (like definition, code, example, summary, etc).

Using the proposed markup language, a teacher can specify the content, just once, in terms that he is comfortable with, namely sections, example, code, explanations, etc; along with dependency between the parts of the content and any restriction on the content. Any content developer can use this specification directly to create content for a specific CMS. This will also reduce the loss of information during the content development.

Content in PCML needs to be converted into structure and format of various CMS for use in practice. By using a knowledge base, mapping the various constructs of PCML to suitable directories and File structures of a specific CMS, a fair amount of this work is automated. Such a converter takes input from the content in the PCML format and develops the content in the intended CMS. It will organize the content in CMS such a way as if the content developer with the help of a teacher created it.

Converter has been developed for Drupal (Open Source CMS) and Vasistha (in-house developed CMS for C-DAC, Mumbai). Drupal and Vasistha have different methods for storing content. Drupal uses MySQL as database for storing content. Vasistha uses flat files. They have different organizational structure for content as well.

Current development includes a web interface for teachers to use PCML, and enhancing PCML for capturing adaptive nature of content.

Software for Other Applications

3D Virtual Reality and Visualization

The Real-Time virtual 3D tour of Nek Chand's Rock Garden, Chandigarh is a simulated walkthrough of the Rock Garden for persons who are unable to visit the heritage site. Trees, walls, stoned pathways, sculptors, huts, wells, waterfall have been created virtually to provide a true-life experience of actually visiting the Rock Garden.

This project was developed using latest graphics technologies like Microsoft® DirectX® APIs, 3DS MAX®, Adobe® Photoshop®, Microsoft Visual Studio.NET and provides rich user experience with features like Digital Photography to enhance the reality of a virtual scene, Textures and Lighting, Collision Detection and Response, Sound, Interactivity using user navigational camera, Optimisation of the 3D model database for better graphics results.

e-Savya – e-Saral Vyapar Suvidha

C-DAC has developed an “Affordable Supply Chain Management System for the SME sector titled ‘e-Savya’ (e-Saral Vyapar Suvidha). The solution consists of functional modules such as inventory management, sales, procurement, shipping and receiving and user management. IIIT-Hyderabad has also partnered C-DAC in the development of workflow, accounts modules. The salient features are user friendliness, customisable GUI, interoperable at OS, browser and database level, and a web-based solution to facilitate the automation of processes in Small and Medium Scale Enterprises to improve the operational efficiency, resulting in productivity improvement. The field trial of the solution has been successful and is presently in use in the identified industries. The solution was launched during ELITEX 2007 by the Hon’ble Minister for Communications and IT, Govt of India. The solution was presented to the National Manufacturing Competitive Council to explore the wide spread use of this solution in the SME sector. This solution development was supported by the Industrial applications division of the DIT.

JATAN: Virtual Museum Builder

JATAN: Virtual Museum Builder is a specialized digital library system for museums. It has been enriched further based on the user feedback. The new developments to JATAN include enhancements in the search mechanism, user administration module, Support for various types of databases and web servers, easy and elegant user interface design. The online-help for JATAN and the User Manual has been prepared by taking the help of technical writers. Raja Dinkar Kelkar Museum, Pune has been using JATAN system for past one year. So far they have integrated approximately 5000 records. JATAN has helped the museum in boosting the museum modernization and fund raising initiatives. C-DAC has developed another software named JATAN: Compliance Enforcement Tool (JCET) to complement the main system. It has been deployed at the Kelkar Museum, Pune for trial purpose. This has proved helpful in monitoring the digitisation activities and enforcing certain quality guidelines. JATAN software is also deployed at the Prince of Wales Museum, Mumbai. They have integrated approximately 500 records with rich historical information. Software updates and technical support are provided to both the museums regularly. It has helped in strengthening the relationship between these museums and C-DAC.

The Monetary Museum of Reserve bank of India, Mumbai and Salarjung Museum, Hyderabad have shown interest in procuring JATAN: Virtual Museum Builder. After studying their requirements, detailed project proposals have been submitted to them.



Virtual Museum lab at Raja Dinkar Kelkar Museum, Pune

JATAN: Conservation Reporting Tool

JATAN: Conservation Report Tool is a Pocket PC based software application. It has been designed for conservators who are responsible for restoration and preservation of antiquities in the museum. Conservation is an intense technical work. It is very hectic, as the museum conservator has to observe each object and fill up the paper format for noting the conservation requirements. The documentation includes details like the dimensions and weight of object, its material, place of damage, the cause of damage, the type of chemical treatment recommended, cost estimate and urgency. Treatments differ on the basis of the material of the artefact e.g. ivory, wood, textile, glass, leather, copper, bronze, etc. The conservators can easily carry this Pocket PC based tool to any

object located within the museum premises. They can record the object's condition, damage information, treatment priority on the spot. The in-built camera of PDA is used to take the photographs of the objects. The photographs along with the information gathered by conservator are later transferred to the main JATAN system using wireless networking for report generation and analysis. It helps museums to keep track of the progress of work, history of conservation, selection and application of preservation techniques.



The Watershed Game Project

The Watershed Game project is an attempt to foster inclination amongst villagers to undertake watershed treatment activities in their village. In order to eliminate the technology barrier faced by villagers playing the game, we have opted for a touch screen based interaction. The interactive 3D Trainer allows villagers to perform treatments on a virtual terrain generated using data obtained through satellite height map imagery. The game demonstrates interactive 3D visualization capability for large terrains along with accompanying vegetation, cattle, and 3D models of villagers while maintaining acceptable frame rates.



Indian Quality of Service test-bed Network (IQNet)

IQNet is a joint project along with IIT-Mumbai, Kharagpur, Chennai and Delhi, IISc, Bangalore and ERNET. The aim of the project is to set-up a nation wide QoS test-bed to try out various applications. The research activities include Measurement Initiative, VoIP Initiative, and Policy based QoS Initiative. Expected outcomes of the project include providing QoS in the Internet, interplay with non QoS networked applications, and control and management of QoS in IP networks.

Natak-3D

NATAK-3D is a tool that lets users create three-dimensional dramas. A user can create a drama using the NATAK-3D editor and play it for the audience using NATAK-3D Viewer.

A drama consists of various scenes. The user is allowed to set up each scene using available props, textures and lighting effects. They are also given a list of available characters that they can use for their drama. These characters can be animated and assigned dialogues.

A drama created in the NATAK-3D Editor is saved as a NATAK-3D script file. This file can be loaded into the NATAK-3D Viewer and can be played as an animated movie. Play scripts can be provided online for download and those interested can just download and play them; provided, that they have installed the NATAK-3D Viewer.

NATAK-3D is aimed at aiding general users to bring plain text to 'life'. It has potential in aiding just about anybody from playwrights to teachers, from students to HR managers. A teacher could use it for her moral science presentation, an HR manager for a training video and a student for a presentation on human values.

Genetic Algorithm

The project investigates the application of Genetic Algorithms to solve the problem of assigning papers to referees based on the various constraints posed both by the paper and referees.

Any conference requires papers to be reviewed for selection. In the call for research papers, a conference lists its areas of interests, which need not be strictly disjoint or hierarchical. Each paper arrives identifying area(s) to which they belong to and each referee has his own areas of interest(s) in which they are willing to review papers. Moreover, a preset minimum number of referees need to be assigned to each paper without overloading a referee beyond his specified maximum.

The above problem is being used as a base to investigate genetic algorithms for similar manpower resource allocation problems where both resources and demands are heterogeneous.

Project Management Application Suite for R&D Organizations

Project Management Application Suite for R&D Organizations (ecProjects) is basically a Project Portfolio Management cum Project Activity Monitoring Package being developed for catering to the project management needs of application oriented R&D organizations.

Small and Medium Applications for Rural Technicalization

Applications developed under this project are:

- Vyapar, a web based application to facilitate interaction between buyers and sellers.
- Pradarshini - An online 'showcase' for rural artisans and handicrafts people to market their products.

Both the above applications have features for product modelling, user management, as well as advertisement management.

India Development Gateway (InDG)

InDG project activities were multifaceted with the project staff in place. The major focus areas during the period were that of establishing partnerships for content (sharing, validation and translation) and outreach activities, development of multilingual portal using the CMS Plone and content collation in the identified sectors of Agriculture, Primary education, Rural energy, Health and e-governance. The portal now hosts content in Hindi, Tamil, Telugu and English in the identified sectors of InDG. Two State level Multi stakeholder workshops were organized to identify the information needs of development stakeholders and the related content providers in the sectors of Agriculture and Primary Education in Andhra Pradesh. A one-day workshop to train the professionals from NGOs on e-learning was also organized by the InDG team. The team members facilitated a tutorial on Content generation and presented a paper on InDG at the International seminar on Information for Socio Economic Development (ISED) 2007 held at

Bangalore. A Quarterly newsletter titled “Gateway to India’s Development has been developed in all the four languages of InDG for wide dissemination of the portal.



Multi-lingual India Development Gateway (InDG) Portal

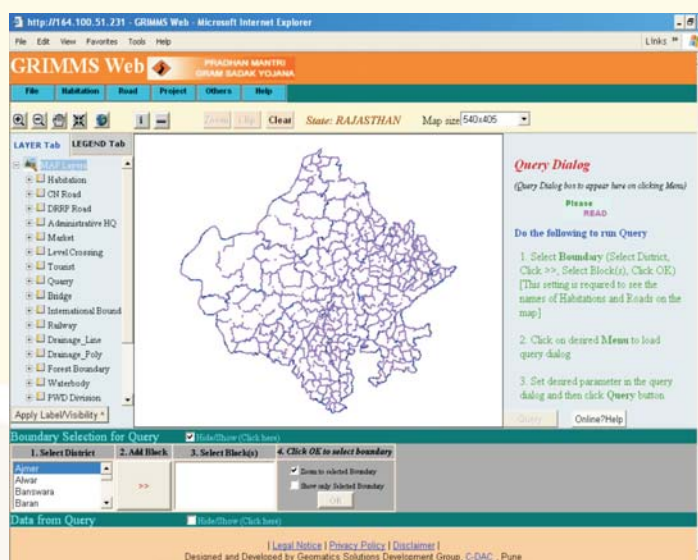
GIS Enabled Software Solutions

NatGeoDC

National Geospatial Data Clearinghouse (NatGeoDC) is aimed at providing a practical solution for collection, aggregation and distribution of spatial data on different themes on a common defined set of standards and formats with performance and security of a Data Grid through a web based single window system. It is created as a proof-of-concept for the GIS data. In this system, the spatial data is physically distributed on systems, which are part of GARUDA grid. The NatGeoDC portal provides modules for querying and retrieving spatial data based on meta-data, theme, location and data name. This portal also provides functionality to display spatial data based on open source GIS applet.

GRIMMS

The Ministry of Rural Development, Government of India, is currently implementing a major programme, Pradhan Mantri Gram Sadak Yojna (PMGSY) aiming to connect all habitations above population of 500 with all-weather roads. An Online Management and Monitoring System (OMMS) was developed by C-DAC to effectively monitor and manage various activities under the programme. Using this system, the Public Work Department (PWD) engineers have created all the non-spatial datasets related to the programme for the whole country, which is being updated over the Web on a regular basis. To make best use of this comprehensive database, a GIS interface has been created for it. Spatial database of pilot states of Rajasthan and Himachal Pradesh is generated from 1:50,000 scale maps of PWD with Survey of India digital data as the base map. The spatial database is linked with the OMMS and a standalone as well as Web-based GIS interface, named as GIS-enabled Road Information Management and Monitoring System (GRIMMS) is developed. GRIMMS, contains a range of user-friendly menus for data updation, query, analysis and report generation. The system is now operational in the two states and is being used for effective management of PMGSY and various state level programmes for construction, improvement and maintenance of rural roads.

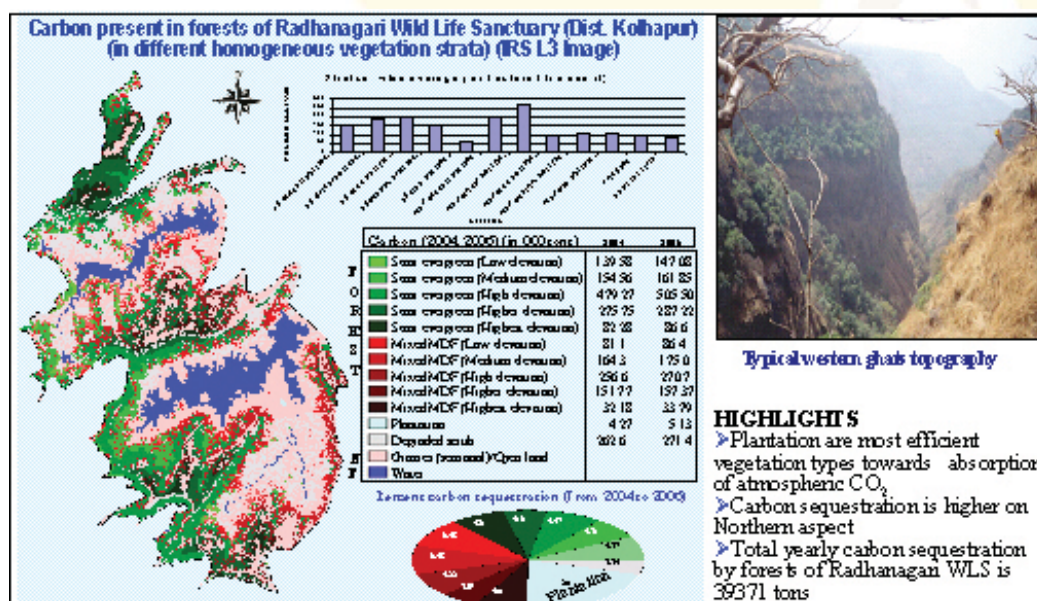


Thematic Layers Delineation

National Informatics Centre (NIC) is implementing a project on 'Spatial Data Infrastructure for Multi-Layer GIS for Planning' for Planning Commission. The project aims at creating up-to-date information regarding Landuse/ Landcover, Wasteland, Geology and Geomorphology of entire country using Indian Satellite (IRS-LISS III) data. C-DAC has generated data for the States of Rajasthan, Gujarat, Maharashtra and Goa.

ISRO-GBP

Carbon dioxide (CO₂) is a major green house gas responsible for global warming. Forests absorb (sequester) CO₂ through the process of photosynthesis and help in controlling the fever of earth. Under the Clean Development Mechanism (CDM) India can win big dividends by reducing the level of CO₂ by planting trees. It is therefore necessary to understand the process of forest carbon dynamics at larger spatial scales to know the accurate CO₂ sequestration. Satellite remote sensing coupled with ground based observations is very effective, not only in studying forest carbon dynamics but also in identifying the most suitable sites for erecting plantation using multi-criteria modelling technique taking different enviro-climatic, socioeconomic and legal criteria into the consideration. Under this project C-DAC has studied the patterns of forest Carbon dynamics in Western Ghats of Maharashtra.



Decision Support System for District Planning

A district being the main entity within the state has to handle various activities like Education, Health, Transportation, Irrigation, and Power. A Decision Support System was configured to manage formulation and flow of information within the District and from District to State level. This activity required integration of data from various departments within the district, analysing the data and planning. The GIS based Decision Support System developed by C-DAC provides the IT framework for information handling, leading to planning activities in respect of Education, Health, Roads, Irrigation, and Power etc.

The system has been successfully implemented across eight districts from Uttar Pradesh and Haryana. It is intended to roll over further to another two districts from Himachal Pradesh.

Low Cost GIS Tools

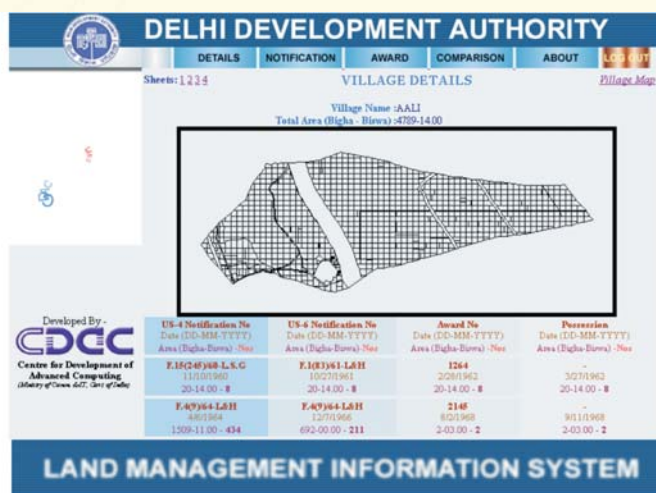
In this project design and development of low cost GIS Tools for the following has been taken up:

- Thematic mapping
- Spatial and Non spatial analysis
- Map viewing
- Multi-layered and Multi Levelled mapping.
- Web GIS Application for Internet and Intranet.
- Compatibility with other software.

The product named as Geo Carte has been tested for Desktop based application and efforts are intended to continue further for a Web-GIS Solution.

Land Management Information System (LMIS) for Delhi Development Authority (DDA)

LMIS for the DDA, involving automation of land records, land acquisition and utilization with digitised maps integrated through the GIS stream, was taken up by C-DAC. In the first phase, village maps of Delhi have been digitised and integrated with its attribute data. Application software was developed for GIS based analysis and MIS reporting. In the second phase, web-based GIS application was developed for dissemination of land information across various departments/ locations for all the available data. The system is under final phase of implementation. It is planned to formulate the system into a customisable product with a generalized form catering to the needs of other development authorities.



Land Management System for MIDC

C-DAC has designed and developed a Web based GIS Enabled Land Management System for the Maharashtra Industrial Development Corporation. The Land Management System is an effective tool that captures the land allotment process at Region Office level of MIDC which encompasses various stages like allotment, lease, extension, transfer, mortgage, surrender, etc. of Industrial and other types Plots. Some of the functional modules of this are, Acknowledgment of application, Receipt of application, and Reminder of notice, Show Cause Notices Reports, Revenue related reports, etc.

Software for Web Portals

Human Resource Portal

The project covered the development and implementation of a portal for providing easy to use web based services to the institutions and officers for their HR management functions like employee records maintenance, monthly payroll computation, real time reporting on employees, etc. and self service functions to the employees for preparation of pay bills, filing of claims (medical, tour, etc.) computation of tax projection statements, preparation of IT returns, etc. The portal also provides facility for the Health Department to provide health care information to the public through Internet. The software modules are developed as web oriented application using J2EE technologies with ORACLE RDBMS.

HR and Payroll functions of the portal are already implemented at the office of all the five Directorates of The Department of Health and Family Welfare - Directorate of Health Services, Directorate of Indian Systems of Medicine, Directorate of Homoeo Medicine, Directorate of Medical Education and Directorate of Ayurveda Medical Education. The implementation was carried out and pay bills for the respective staffs in each office are generated online in treasury format (TR-51). Connectivity is provided between Health Directorates and State Data Centre.

The HR module of the portal can manage Attendance and Leave records, Appointments, Increments, Pay Fixations/ Re-fixations, Transfers/ Promotions/ Deputations, Confidential Report, Awards and punishments, Training and Skill improvement, Pension processing, etc. The Service Book of each employee is automatically maintained.

The Payroll portion of the portal consists of setting up and maintaining of Master Payroll Data for Employees. Monthly salary processing includes preparation of Pay Bill (TR-51 format), schedules and reports, employees' pay slip, etc. The system will also act as an aid for preparation of bills for self-drawing officers. This system has link to the personnel module, to collect the latest information regarding leaves, increments, promotions, etc.

The system also provides Income Tax projections to help the employees for planning their savings and payment schedules. It also gives various mandatory organizational reports to be submitted to the Income Tax office.

As part of the HR Portal an Ayurveda, Homoeo and Modern Medicine portal has also been implemented.

The Ayurveda portal is aimed at providing service to the public, doctors, researchers and students. Detailed information about ayurveda and a brief introduction to Sidha and Unani system of medicine is provided through the portal.

The Homoeopathy portal provides personalised service to the public, doctors, researchers and students. It describes the homoeopathic treatment system. Various health preservation techniques and medicines are described.

The Modern medicine portal is aimed at providing information to the public regarding health preservation. This also provides details of Government Institutions in Kerala, dealing with health preservation like hospitals, community health centres, primary health centres, dispensaries, blood banks, ambulance services and laboratories. Details of State level and National level health programmes

organized are made available to the public through the portal. Provision to download Government orders, documents, white papers, publications, public health acts, etc. is also provided.

The portal facility is accessible by the public via the URL: www.healthkerala.gov.in

Puducherry Revenue Web Portal

The Puducherry revenue web portal is a bilingual web portal in Tamil and English. The web portal contains details and functions of the various offices under the Revenue department including the survey and land records department, the Legal metrology department and the Excise department. The Organizational set-up of the department, the services rendered, the details on disaster management and various legislations are readily available. The various functionaries, functions, acts and rules, citizen charter are available for each office. Various forms related to the department are published, so that the public can download and use them. The web portal allows for filing petitions online by the public using the ePetitions link. The guidance rates of the properties are also available online.

Student Portal

This is an effort to encourage students interested in taking up serious and useful projects for their term-paper and course project. This is a comprehensive framework in place for people to propose project ideas, for groups to register, for mentors to monitor, and so on covering the entire range of tasks.

Innovation Portal

Innovation Portal is an effort towards encouraging and promoting inventions and innovations among students and the youth in India. The project was conceived jointly by Intel India, Confederation of Indian Industry, and the Department of Science and Technology. OSSRC at C-DAC helped to realize it through setting up of a comprehensive portal. The portal acts as a platform where people can post their innovative ideas, products, or technologies in various fields and analyse or build on other's ideas, and also post problems requiring innovative solutions. This way the portal provides innovators with a canvas to project and explore their ideas.

The portal was developed completely using open source software including Drupal, PHP, JavaScript, MySQL, etc. Further enhancements to facilitate interaction among the various user groups are in progress.



Shiksha e-Learning Portal

Shiksha e-Learning Portal is a Teachers' Platform for sharing, creating, collaborating, and discussing their teaching subjects and associated contents.

The portal provides a platform for teachers to showcase and share their creativity. Any innovation in term of teaching tools, techniques, methodology which has worked well for one's students or which they feel would work well for students or would help the teaching community, can be discussed under this portal. Sharing of content and ideas, help reduce the duplication of effort in creating something that already exists. Shiksha e-Learning portal provides an environment to build a good repository and authenticated content created by teachers that could be made available for any one. They can also add various tools that they have used. The site offers contents of various subjects in various languages that can be downloaded. The site name is: www.eshikshaindia.in



Department of School Education, Government of Punjab Website

C-DAC has designed and developed a web site for the Department of School Education, Government of Punjab. It caters to the recruitment of headmasters, lecturers, PTI, BPEO's, DEP's, and teachers. It also caters to preparation of results, appointment letters, gazette notifications, etc., and admission to the ETT course in Punjab.

DIT CMUS Website

The scope of the project covered the upgradation of the existing website of the DIT to international standards in design, aesthetics, and ease in accessibility of information.

The new site provides the following features:

- CMS based website
- Log audit module for tracking admin activity
- Types of Roles in DIT CMUS
 - Super Administrator
 - Administrator
 - Content Manager
- Special security measures:

- Maximum of 4 attempts allowed for login
- Auto complete for username and password disabled
- SQL injection bypassing proper authentication
- Page is not saved in the cache memory, every time the request is posted to server. If page is not refreshed for 10 minutes then the session expires and user has to relogin
- Back button is disabled in the browser

VLSI SMDP II Website

VLSI website provides the latest information and tutorials from experts on VLSI and centralized databases of the manpower developed for promoting VLSI related activities for the benefit of premier institutes in India, including the IITs. It incorporates interactive applications like discussion forums, mailing list, online forms, event submission etc. The project is developed in JAVA.

IITM Website

The scope of the project covered revamping the existing website of ABV-IITM to conform to international standards in design, aesthetics and ease in accessibility of information for an institutional website. The existing static pages were to be transferred into the new layout using .NET technology.

The new design is highly scalable thus we can increase the content to any level and still have enough scope on each page to accommodate more. The home page can display content, latest information, important deadlines, important updates, etc.

Public Health Department, Maharashtra Website

A comprehensive web site for Public Health Department, Maharashtra has been designed and developed. The content of the web site has been distributed over a number of static pages as well as through a host of interactive and dynamic web enabled applications. The site can be accessed through the URL: <http://maha-arogya.gov.in/>

Professional Electronics Including VLSI and Embedded Systems

Power Electronics

National Mission on Power Electronics Technology

The objective of this programme is to launch a national level effort in strengthening power electronics technology in the country, and thus attain the capability to become a dominant global player in this area in the next four to five years time. The underlying objective is also to make significant contributions in the area of electronics manufacturing in the country through R&D in power electronics. The project is funded by DIT and is of five years duration. This programme will facilitate research, development, deployment, and commercialisation of power electronics technology, by ensuring participation of academics, R&D and industry. Futuristic technology development projects and user specified sponsored projects would be taken up in this Programme. Premier academic institutes like IISC, IITs, Anna University, Bengal Engineering and Science University, etc, and user/ manufacturing industries of PE systems in the country will be networked to realize the mission. Projects will be implemented by one or more participating agencies, and will be coordinated by the Nodal Centre at C-DAC. A National Steering Committee comprising of eminent experts from different agencies and institutes in the country, under the Chairmanship of Dr.V.K.Aatre, Former advisor to RM, guides the activities of NaMPET.

Power Assisted Bicycle

Motor assisted pedal cycles are two wheeled vehicles in which primary motive force is achieved by human rider while the motor engages only to augment human effort. It is conceived as a conventional human powered bicycle with an auxiliary add-on system for motor assist. The user is not required to operate any special controls for the functioning of the auxiliary motor. The rider of the vehicle pedals the cycle just as when using a conventional human powered bicycle. The force exerted by the rider is sensed by the system and the motor augments the rider's effort. As the tractive force exerted by the rider exceeds a set limit, tension sensor gives signals to threshold detector and actuates the motor for assistance.

Low Voltage Embedded Real Time Controller for Three wheeler series HEV

The objective of the project is to develop HEV for low emission auto rickshaw as passenger carrier, for Kerala Automobiles Ltd., a public sector company in Thiruvananthapuram. The scope of technology development is in low voltage electronic control hardware with DSP and CAN, development of Hybrid power source with battery and alternator, CAN based network for inter-module power control, and development of fine-tuned four stroke engine for HEV application. Presently the first prototype is in trial phase.

Full Spectrum Simulator

A real time simulator is an extremely important tool for power systems and power electronics systems. Given the nonlinear and complex nature of the systems, analytical approaches are usually impossible. As a result, several commercial simulators for such systems have emerged in the market. While there are some public-domain simulators in existence, their capabilities are inadequate to handle realistic power system and power electronics problems. Commercial simulators that are powerful enough to tackle these problems are expensive in the Indian Context. Further, they come with a limited number of licenses.

The purpose of the project is to develop a Full-Spectrum Simulator (FSS) using the expertise available in the academic institutes and R&D labs under the National Mission on Power Electronics Technology (NaMPET). This will make it an excellent simulation tool for practicing engineers, R&D professionals, industries, college teachers and engineering students.

Static Power Balancer

The objective of the project is to develop technology to compensate the dynamic unbalanced power drawn by single phase or unbalanced loads, at the point of common coupling (PCC). Often the loads in the distribution feeders are either single-phase or unbalanced three-phase loads. The railway traction load along with arc furnace constitutes the most important sources of imbalance in the distribution system. This imbalance causes under utilization of power system infrastructure like transformer, switchgears, and power cable/ transmission lines. The unbalanced load also introduces negative sequence components in the grid, which is not a favourable condition for the AC generators. This also causes imbalance in voltage, which in turn affects several other connected load. Therefore, a compensation device, Static Power Balancer, should be designed to transfer active power between the phases in order to create a balanced load as seen by the grid. The Static Power Balancer is based on static converter topology connected to the grid through coupling choke. The controller will sense the load currents in all three phases and assess the amount of unbalance. The switching of the converter is modulated in such a way that the converter injects negative sequence current component into the grid at the PCC to achieve the load balancing at the grid.

Hazardous Object Removal System

The objective of this project is to develop a remotely operated mobile platform to pick up and remove potentially hazardous object from an environment where it might cause harm to humans.

Bus Paralleling Controller with CAN Interface for Power-up-scalable Converter Modules

The project aims at the development of the Controller and efficient control algorithms for enabling modularity and bus Paralleling of High Power Converters employing high-speed Controller Area Network (CAN) bus. This technology can be used in areas of power control like UPS Systems, AC Drives, STATCOMs etc. Existing parallel redundant indigenous technology requires a common panel, which means this is not a true redundant system and also restricts the number of Converter modules in parallel. The current unbalance between systems is in the order of minimum 10% of the rated value.

The new paralleling scheme can support “n” number of units since no common elements come into the picture. The system uses the fast space vector control with the aid of digital signal processor and also the fast CAN bus helps to meet the specific requirements.

Power Conditioners for Fuel Cell Power Plants

Fuel cells have been considered as the primary energy source for the next generation electric utilities. In addition to higher efficiency and zero pollution emissions they are low noise devices and do not require frequent maintenance. Fuel cells produce DC voltage from hydrogen-rich fuel gas and air that flow over two cell electrodes. This development is envisaged for an effective power conversion and use of the energy from fuel cells. Development of power conditioners for 1kW and 3kW Fuel Cell Power Plants with scope of extension to higher capacity have been taken up in this project.

CAN based Embedded Controller for Automotive Application

The Controller Area Network (CAN) protocol has found wide acceptance in automotive in-vehicle applications due to its high performance, low cost and configuration flexibility. HEVs are the present potential choice for environmental friendly public transportation systems. Their safety and functionality can be improved and many value added features can be easily incorporated with CAN based distributed control. In HEV different electrical systems are functionally interconnected, requiring exchange of information accurately in real time. The CAN controller reduces communications burden on the host CPU, thus allows running its algorithms for better real time power train control. The differential physical layer improves data exchange integrity under EMI from power switching systems in this application.



PV Inverter with Utility Interconnection

The technology developed is for 1KVA rated High Frequency link inverter operating from solar energy suitable for home lighting applications. Control strategies are implemented on Digital Signal Processors (DSP) based hardware with single phase MOSFET and IGBT based inverter circuits.



Electronic Paralleling of UPS Systems

The technology for Online Double Conversion UPS System with Electronic paralleling for complete power protection and improved Power Quality, suitable for Medium/ High Capacity range, has been developed. The present technology in most of the indigenous UPS systems adopts paralleling using passive components and switchgears, or through a sluggish control of the phase angle and amplitude. This method limits the flexibility, reliability and efficiency of the systems. In the new efficient electronic paralleling scheme developed, the paralleling is achieved by instantaneous correction of active and reactive power by field-oriented control using Digital Signal Processor based powerful control algorithms. Also, paralleling with grid will enable the UPS systems to supply loads with inrush currents. Through this development, the technology for electronic paralleling of UPS systems is indigenously available for the UPS manufacturers of the country. This development enables higher redundancy for power in critical installations, as well as the upgradation of power rating with standard modules.

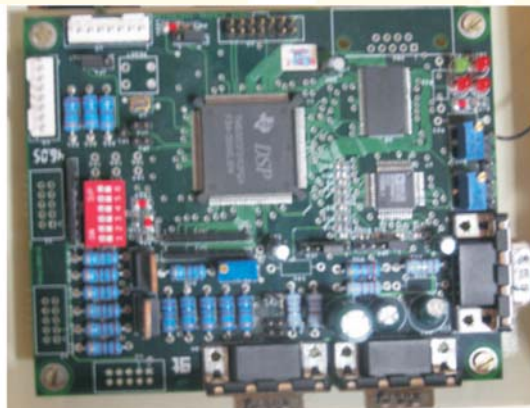


Single Phase Dynamic Power Compensator

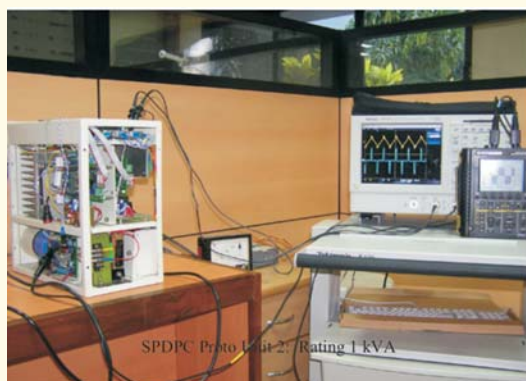
Dynamic Power Compensators for single-phase grid supply in order to compensate the Reactive power requirement of the load dynamically with IGBT Converter topology has been developed. Control algorithm development in single-phase topology is a challenging development work. There is rising demand for power factor compensation in single-phase loads in official establishments and agricultural pumps in the country and abroad. The developments so far carried out in pf compensation area are in the high power, three phase systems. Since the single phase medium and low power connections are in large numbers, introduction of a cost effective and reliable single phase compensator is expected to have far reaching implications in energy saving. The introduction of Dynamic Power Compensators in commercial establishments and agriculture pumps will drastically bring down the current drawn by their loads by compensating their reactive part. There is further scope for development of single-phase active filters for filtering the harmonics currents in the load current. DPC with 10kVAR rating, suitable for commercial application is developed through this project, and the technology can be used for other power ratings also.



SPDPC Proto Unit 1: Rating 10 kVA



SPDPC Digital Controller



SPDPC Proto Unit 2: Rating 1 kVA



SPDPC Proto Unit 2: Fully assembled

Process Control Systems

Intelligent SCADA in Retrofit Automation

The system will eliminate the requirement of large quantity of cables normally required for Retrofit Automation in stringent space available. It is an excellent tool for automating a chain of power stations or process plants. The Intelligent SCADA system is planned to be demonstrated in one of the running water treatment plants.

Distributed Intelligent SCADA for TCFHP PS-II and III

The objective of the project is to monitor necessary plant parameters and implement centralized computer control system in order to achieve efficient and economic operation of power stations. Wireless communication system is employed for fast transfer of data among power stations. The system considers Data acquisition of nearly 990 signals at PS-II and 1050 signals at PS-III and provides automatic control system for the plants using the Intelligent Process Controllers (IPCs) and Distributed Control Nodes (DCNs) designed and developed at C-DAC.

Earlier C-DAC had successfully commissioned a SCADA system at TCFHP PS – I, with measurable benefits in terms of increased productivity, ease of operation, better diagnostics, etc. This was fully funded by WBSEB. The SCADA system at PS-I has been functioning successfully for the last five plus years.

IEC 61499 Based Intelligent Device

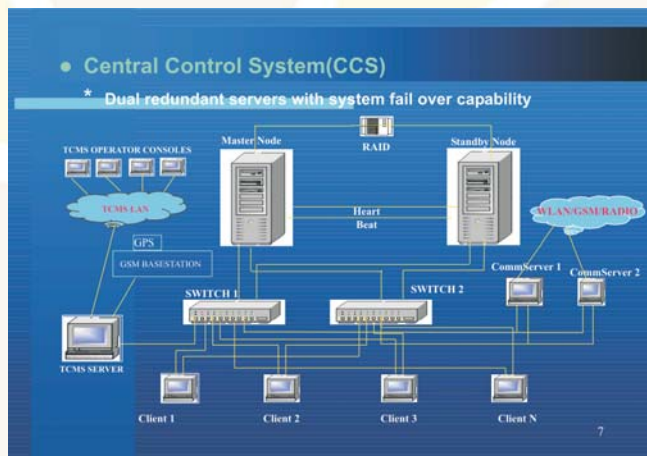
The new emerging standard IEC 61499 defines a software component concept, as well as provides Function Block architecture for industrial process measurement and control systems (IPMCS). It describes how a distributed control system can be created by means of interconnection of software components. The standard is an attempt to improve the flexibility of software design technology.

In IEC 61499 standard, the IPMCS is specified as a collection of devices interconnected and communicating with each other by means of one or more communication networks. Each device contains one or more interfaces and zero or more resources. A resource is a functional unit with independent control of its operation, which may be created, configured, parameterised, started up and deleted etc., without affecting other resources within the device. The interfaces provide the device the ability to interact with processes or with communication interfaces.

The function performed by the IPMCS is specified as an application, which may reside in a single device or be distributed among several devices. The application consists of a Function Block network with data connections and event connection.

Enhanced Features for Power SCADA System

The objective of this project is to develop and incorporate enhanced hardware and software features in the sub systems of Central Control System (CCS), Substation Control System (SCS) and Distributed Nodes (DN), which have been already developed as part of the Distribution Automation Project for Thiruvananthapuram City.



Autonomous Remote Access Device for Remote Diagnostics and Monitoring

This project aims at developing an Autonomous Remote Access Device (ARAD) that can be used as an aid to the expert involved in diagnostic and monitoring activities in SCADA and other process control environments. The design of this cost-effective, portable product is based on a flexible architecture.

The product comprises of a Handheld device running LINUX, functioning as the intermediate server/ client machine, Data acquisition tool (both server and client), with all the necessary drivers for Blue tooth /802.11b/GSM/GPRS interface, Server software for portable device, and a communication protocol based on XML/SOAP.

Embedded Controllers for ASTeC

This is a national level R&D project involving Research, Development, Demonstration and Technology transfer leading to production and commercialisation. The programme envisages technology generation in the areas of Colour and Level Sensor Systems, Intelligent Actuators for Process Control, Wireless Sensor Network System, Advanced Control Algorithms, Optimisation Algorithms, Plant Models and Data Fusion Models, Recognition and Decision-making System for Diagnosis, and Root Cause Evaluation of alarm and processes in Process Control Systems, Multi- Agent System to provide operator guidance for fault detection, isolation and restoration, General Purpose Embedded Controller and Intelligent IO modules, Single Board Controllers, Low Power Controllers, Communication Configurator, Flexible open SCADA Software, SCADA Security Tools, Network protocol and Associated Software, Configurable embedded CRM and ERP interface.

The above Research and Development is structured in four Technology programme themes viz. Perception, Control, Learning, and Systems. The benefits of the technologies generated will be illustrated with the help of Demonstrator and Explorative projects.

Development of IP Cores

Sigma Delta ADC core

This project aims to design and develop a Sigma Delta ADC core for ASIC embedding. Sigma Delta ADC is an over-sampling ADC that uses over-sampling and noise shaping to improve signal to noise ratio (SNR). Sigma Delta technology offers system cost

savings because the analog anti-aliasing filter requirements are considerably less complex, the sample-and-hold circuit is intrinsic to the technology due to the high input sampling rate and the low precision A/D conversion. Sigma Delta ADCs are widely used particularly in applications where high precision is required and the signal band is relatively small, such as in audio processing and instrumentation. Multi-bit resolution, linearity of the conversion characteristic, and effective digital filtering of the converted signal combine to produce high conversion accuracy in a Sigma Delta ADC. This makes it suitable for high accuracy systems. Also, they are inherently insensitive to process imperfections such as component mismatch.

Sigma Delta ADCs consist of two basic blocks: a sigma-delta modulator and a digital decimation filter. The modulator block, which is mostly analog, coarsely quantizes the analog signal into a 1-bit sequence of ones and zeroes at a high sampling rate. The decimation filter, which is fully digital, filters out the noise and converts the one-bit data stream (at high sampling rate) into a 16-bit data stream (at low sampling rate). Decimation is done in more than one stage since filters are expensive to build at the elevated sampling rate.

Design and testing of the decimation filter has been successfully completed. Testing of the modulator block is in progress.

Radiation Monitor Board

Radiation Monitor Board is an 8051 microcontroller-based board used in radiation monitoring applications. The aim of this project is to replace an existing 8051 microcontroller-based board with an FPGA based board, integrating the in-house developed IP cores viz. 8051 equivalent IP Core, Ethernet core, UART core, and ADC/DAC interface into a single FPGA, to minimize the number of external components. The board has 8 analog inputs and 2 digital outputs. There are also four 8-bit general-purpose digital I/O ports and one 4-bit port with high current output drivers for relays and hooters. The external interface is through RS232 and RS485 serial ports, besides network compatibility over TCP-IP. A 5x4 matrix keyboard interface is also provided. Parameters could be stored in an on-board 4KB EEPROM with a SPI-compatible interface, designed into the FPGA. Data memory is constituted by a battery-backed 64KB NVRAM with an integrated RTC.

32-bit RISC Processor IP Core

C-DAC has successfully designed and developed a 32-bit RISC processor IP core 'ER902', which has been proven on silicon and embedded in two products. This project aims at developing a System-on-Chip (SoC) architecture based development system built around the ER902, which involves the design and development of MMU, Cache, Coprocessor, and AMBA compatible interface resulting in performance enhancement of ER902. The development system will be implemented in an FPGA based board integrating various other in-house developed IPs viz., UART, USB, Ethernet, Timer, etc. to build a full-fledged customisable 32-bit RISC Processor based embedded system prototyping platform. The development system can be used as a test bed targeted to a host of embedded applications like portable computing, information systems, consumer products and other portable instruments, where power and speed are of prime concerns. The platform will be offered as a full function product for ASIC integration, complete with design framework and test suite.

The design of MMU, Cache, Coprocessor, and AMBA compatible interface has been successfully completed. Validation in silicon is in progress.

USB_OTG Controller IP core

The USB has become a popular interface for exchanging data between PC and peripherals. An increasing number of portable peripherals are using the USB interface to communicate with PC. USB traditionally consisted of a host-peripheral topology with the PC being the host and the portable peripheral being a dumb device. Many of these portable devices would benefit from being able to communicate to each other over the USB interface without a PC. USB On-The-Go (USB OTG) is a supplement to the USB2.0 specification that augments the capability of existing mobile devices and USB peripherals by adding USB host functionality for

connection to USB peripherals. The aim of this project is to design, develop, and validate an advanced IP core of USB OTG for ASIC embedding, thereby providing a low-cost connectivity solution to consumer portable devices such as mobile phones, PDAs, digital still cameras, MP3 players, etc. A technology-independent VHDL based fully synthesizable code will be implemented on FPGA. Also, a Prototype Evaluation Board will be developed for software and product validation by customers using the core.

Asynchronous 8-bit Processor

Asynchronous logic is an alternative style of circuit design that does away with the clock signals of conventional logic, and uses logic modules that are self-timed and that pass results among one another using handshaking protocols. There has been lot of interest over the last couple of decades because of its power-saving potential. CMOS circuits draw current only when they switch, and clocked synchronization means that all the circuits on the chip switch at the same time, maximizing the current transients, which in turn maximize the radio interference. Clocks cause unnecessary power dissipation by generating activity in parts of the circuit that are not doing useful work. Merely distributing a high frequency, low-skew clock consumes significant power. Asynchronous logic consumes zero dynamic power when there is no activity and it also saves power by not driving clock signals.

This project aims at designing, developing and validating an advanced IP core of a clock-less 8 bit Asynchronous CPU, which will be offered as a full function product for ASIC integration complete with design framework and test suite.

Design of the Asynchronous Processor core is in progress.

SATA-II IP core

Serial ATA (SATA) is a new standard for hard drive and storage interface. It has much better features and performance than the existing standard, Parallel ATA, in addition to overcoming most of its limitations. This project aims at developing a SATA Host Controller IP core with a high-speed differential layer using Gigabit technology and 8b/10b encoding, providing a high-speed serial link to mass storage devices. The IP core will be compliant with SATA 2.5 specification, and will be ready for ASIC/ SoC embedding. In addition to the higher data rates, the SATA Controller IP will also provide enhanced features such as hot plug capability, EMI reduction, low voltage signalling and additional power saving features, and more sophisticated data handling commands.

BMI Processor Board

BMI Processor Board is an interface board used in Bio-Medical Instrumentation applications, such as interfacing an ECG instrument to a PC. This project aims at developing a board, which will replace an existing Single Board Computer (SBC), with an overall dimension of 88mm x 54mm. This is developed for BARC, Mumbai. The board integrates the in-house developed 32-bit RISC processor 'ER902', together with 64 KB Flash EPROM, 64 KB Battery backed Static RAM, Battery backed RTC, 16 x 8-bit ADC, 2 Timers, 12 Input lines, 28 Output lines, 4 Interrupts, USB Port, and RS232 Port. ER902 and most of the peripheral functions required for the implementation are integrated inside an FPGA with minimum external components. This board will be a multi-layer board with SMD components to ensure that the board size is minimum. After completion of the PCB Ver.1, PCB Ver.2 is in progress, with enhanced features. Fifty units of this board will be made.

Ethernet MAC IP Core

Ethernet is a local area network developed in 1976, by Intel, DEC and Xerox Corporation. Ethernet uses a bus or star topology and supports data transfer rates of 10/ 100Mbps. The IP core designed will be compliant to IEEE 802.3 standard for embedding into ASIC/ SoC and would be useful for a range of applications like industrial and consumer products. The project deliverable will be a full function MAC Core with Customer Evaluation Module, which can be sold as an IP core product for ASIC integration, with detailed documentation and test benches.

The IP core developed is adaptable to a wide range of system requirements and can be interfaced to 10 or 100 Mbps PHY devices. Similarly, the core will offer a processor independent 16-bit host interface and can readily be interfaced to a range of standard buses through the addition of bridges such as the optional AMBA AHB.

Traffic Control and Vehicle Tracking Systems

Wireless Traffic Controller

This project relates to the study of a novel concept of controlling the Road Traffic Signal without a physical connection between the Traffic Controller equipment and the signal lamps and sensing traffic on the road without digging, using sensors having wireless communication.

Area Traffic Control Systems

C-DAC has designed an Area Traffic Control System (ATCS), with junction controllers having autonomous ability of operating vehicle actuated signalling controls, fully adapted to Indian road conditions. The project had its first implementation in the city of Pune, with the model software running on dual redundant servers in a central location, which acquires information from 38 junctions over appropriate MAN like fiber optic/ leased line and then computes optimum split time, cycle time and off set time for each junction and finally sends them down to the junction controllers. The introduction of the new system resulted in significant reduction in the Vehicle operating costs due to reduced delays, reduction in traffic congestion at the road intersections resulting in visible service level improvements in the road system, reduction in environmental pollution, reduction in noise levels, and reduction in wastage of fuel.



The success of ATCS implementation at Pune prompted the Jaipur Development Authority (JDA) to go for the C-DAC technology when they decided to modernize of the road traffic signalling in Jaipur city in Rajasthan. C-DAC made the supply, installation and commissioning of the traffic signal controllers and associated accessories through its ToT partners M/s. Webel Mediatronics Ltd., Kolkata and M/s. Shakti Enterprises, Jaipur. Control room and surveillance camera installations were done directly by C-DAC.

Under the project, nine junctions on MI Road, Jaipur were brought under the ATCS, 23 surveillance cameras installed and the cameras and intersection controllers networked to the Central Control Room set up at First floor, Office of the SP (Traffic), Yadgar, MI Road, Jaipur. Managed Leased Line (MLLN) was used to network the system. The ATCS application run on dual server and three operator consoles with projection system provided at the Central Control Room.

Vehicle Tracking System

The system consists of a Vehicle Mount Unit (VMU) and a Base Station Unit (BSU). The Base Station Unit is interfaced to a PC. The Vehicle Mount Unit employs a GPS (Global Positioning System) receiver to identify the location of the vehicle and transmit the information to a base station over the network using GSM modem/ MSS/ GPRS/ CDMA. The Base Station Unit consists of communication equipment for reception of messages from Vehicle Mount Unit. The Base Station Software collects the information

and logs onto a database. Web based plotting software uses this information from the database and the position of the vehicle is mapped on to a raster map. This information is then made available either on the LAN or the Web for online display and reporting.

Acoustic and Magnetic Sensor Based Systems

Acoustic Land Mine Detector

The objective of this project is to design and develop a Seismo-acoustic land mine detection and discrimination technique, which does not depend upon the material from which the mine is fabricated whether it is metal, plastic, wood or any other material.

The new technology uses Acoustic-to-seismic coupling and digital signal processing technologies for detection and discrimination of artificial objects, such as land mines, pipes, containers, etc., buried in the ground.

C-DAC is also working on a vehicle mounted detection system for landmines using ultrasonic techniques for military use. The resulting product will not be usable for civilian sector. A need also exists for a simpler, low cost, portable, battery operated, landmine detector with minimal weight. The technology being developed can be used for humanitarian demining (of anti-personnel mines) purpose by the Police, Paramilitary forces, Border Security Force, etc.

Acoustic Thermal Profiler

Temperatures in the combustion zone of a large furnace/ boiler can be in the range of 2000-3000°F. Conventional temperature measurement methods such as the use of thermo couples are not practical. It is possible to measure the temperature using sound waves. Acoustic pyrometry provides a practical approach for the on-line continuous measurement of gas temperature in the hostile furnace and stack environments. The technique uses average line-of-sight measurements between the acoustic transmitter and the receiver. Using multi-path, side-to-side, front-to-back, and diagonal measurements within a furnace volume information can be computed on plane wide average temperature. Deconvolution methods can produce isothermal maps at any given plane of the furnace interior.

Acoustic Tomography System

This project aims to develop an Acoustic Tomography System, which can be used as an Non Destructive Test System (NDT) for evaluating the interiors of the structures like thermal tiles used in space vehicles and moulded Solid Propellants. The techniques developed can later be used to develop Medical Tomography Systems and for Non Destructive Testing of fruits etc.

Magnetic Modelling Software

In order to achieve the objective of reducing the magnetic anomalies created by war ships, it is needed to model the ship to characterize its magnetization properties. The magnetic complexity of the vessel can be defined as a set of analytical formulas. This will involve multiple descriptions of the bulk sources of magnetism to describe the observed field at the sensor depth as the ship traverses an open range. The model is created from the data collected by Magnetometers (sensor) while the ship passes over an array of sensors deployed on the seabed (Range). The track of ship with respect to the sensors will be obtained using differential global positioning systems. The application of the software will be in the areas of degaussing and “deperming” of war ships.

Remotely Operated Submersible

The objective of the project is to design and construct an underwater Remotely Operated Submersible (ROS), which can be controlled by an operator located above water. The operator's station will be connected to the ROS by an umbilical cable to carry power and commands from control station to ROS and video pictures and data from ROS back to the control station.

Acoustic Path Checker

The objective of this project is to develop Acoustic and Ultrasonics based Path Checking System (Obstacle Detection System), which can be mounted on an autonomous vehicle. Autonomous vehicles (AV) are used in various strategic areas. By employing an obstacle detector (Obstacle Early Warning System) the AV can move on its own. The system will detect the presence of an obstacle, which may possibly obstruct the movement of the Autonomous vehicle and give a warning signal so that the AV can change the direction of movement or stop to avoid a collision.

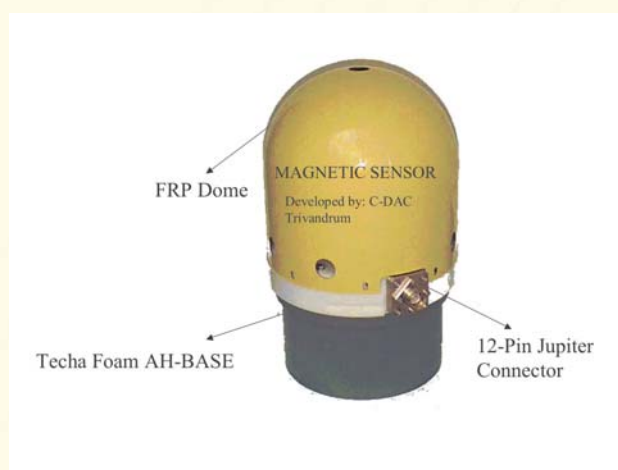
At present such a product based on ultrasonic techniques is not available. The technical challenges are two fold – (i) to get an ultrasonic image with very coarse resolution of the scene in front of the AV, (ii) To decide whether there is an obstruction in the captured scene. The expected outcome of the project in physical terms consists of a prototype unit and documents. The technology developed for the front end of this product will be helpful in developing another product for the visually challenged, the Acoustic Torch.

Magnetic Sensor for Underwater Magnetic Range Applications

The objective of this project is to develop a Magnetic Sensor for Underwater Ranging applications. The design and development of Magnetic Sensor for Underwater Ranging or similar marine applications can support the future requirements of the Indian Navy. This development would also replace the existing imported magnetic sensors used in the UWR project, Goa.

Operational stealth can be considered a measure of the ability of a ship (surface ship, submarine, or other naval vehicle) to operate undetected against specific threats in designated mission areas. It is highly desirable for ships to embark on assigned missions with a degree of stealth that provides a necessarily low level of vulnerability to detection, classification, and localization by threat sensors. Underwater Ranges are meant for Ranging of ships to measure and control its signature. Magnetic Sensors are used for Magnetic signature measurement of ships / submarines with metal hull.

The Magnetic Sensor consists of a sealed enclosure (Electronics and instruments integrated inside) that is resistant to seawater and microorganism attack. Each sensor assemblies are capable of withstanding continuous immersion in sea water up to a depth of 35 meters. The electrical connection to the sensor shall be made via a Jupiter bulkhead connector (REC F14MT 1216) or inconnel connector. Non-magnetic materials are to be used wherever possible in construction of the sensor.



Sonic Ultrasonic Non Destructive Test-System (SOUNDS)

SOUNDS is a system for Non Destructive Testing and Evaluation of materials, using Sonic and Ultrasonic frequencies. Using SOUNDS, the user can measure the velocity of a sonic-ultrasonic wave through the test specimen, and the attenuation of the wave in the material. If the velocity of propagation of the wave in the material is known, the system can be used to measure the thickness of the material accurately. This way, SOUNDS can be used for detecting internal flaws in test specimens, as well as for studying the

characteristics of materials under test. The lower frequencies used in SOUNDS make it useful in situation where common high frequency NDT system cannot be used, like testing of ceramic materials. The semi automatic method of measurement makes SOUNDS a powerful tool in the hands of an expert user, and at the same time permits easy measurements by a non-expert. SOUNDS is capable of measurement in either Single Transducer Mode or in Dual Transducer Mode. In Single Transducer Mode the wave is transmitted into the specimen and the reflected echoes are received with the same transducer. In Dual Transducer Mode, a second transducer is used for receiving the waves after it passes through the specimen. This feature permits SOUNDS to be used even in situations where only one side of the specimen is accessible, like a ceramic tile fixed on the body of equipment.

USPARE Project

C-DAC successfully commissioned a turnkey project called Naval Under Water Range Project (NUWR-Project) for the Indian Navy (NSTL) at Goa. As part of this mission-critical project, Off-shore Systems like Acoustic Sensors, Magnetic Sensors, Under Water Junction Boxes and onshore items like Data Handling Systems, DGPS parts, etc. were developed by C-DAC. After commissioning and expiry of warranty period of this project, NSTL has awarded the Annual Maintenance Contract of the same to C-DAC. As part of maintenance contract, certain parts are to be purchased and kept by NSTL at UWR site, hence this project.

C-DAC supplied 98 systems/ Parts to NUWR (NSTL) as part of this spare supply order. These items were developed using indigenous technology and were inspected and accepted by NUWR at site.

Systems Based on RFID Technology

RFID Engine for Supply Chain Management

Radio Frequency Identification (RFID) is a method of identifying items using radio waves. This is an alternative to the barcode, magnetic stripe or printed label. Like in barcode and magnetic stripe, every item to be identified is given a unique identification number, which is embedded in a 'transponder' or tag, and this tag is attached to each item. An RFID reader will extract the identification number from the tag when the item is in its reading range. As against the Line of Sight requirement of barcode technology, RFID readers can even read tags that are enclosed inside containers. Compared to barcode, magnetic stripe, or printed label, the advantages of RFID include tolerance of mis-orientation and obscuration, lower cost over life and ability to store and retrieve information fast. Nowadays, RFID technology is used in many applications including security and access control, transportation, automated toll collection, supply chain tracking, etc. The RFID system allows retailers to identify potential delays and shortages; grocery stores to eliminate or reduce item spoilage, speed up shopping; toll systems to identify and collect auto tolls on roadways; suppliers to track shipments; and in the case of critical materials, RFID will allow receiving authorities to verify the security and authentication of shipped items.

The aim of this project is to develop an RFID Reader Engine working in the UHF range, capable of reading and writing into tags supporting EPC and ISO standards. The reader sends and receives RF data to and from the tag via antennas. The tag consists of a microchip that stores the data and an antenna that sends and receives RF signal.

HF RFID Interrogator

Radio Frequency Identification or RFID is a new auto-identification technology for physical objects. Like Barcode and magnetic strips, every item to be identified is given a unique identification number, which is embedded in a 'transponder' or tag, and this tag is attached to each item. A RFID 'interrogator' or reader will extract the identification number from the tag when the item is in its reading range. The scope of this project is to design and develop an RFID Interrogator working on 13.56 MHz frequency to support short range applications like point of sales, inventory control etc., in shops and factory floors etc.

Design of HF RFID Reader has been successfully completed. Product engineering is in progress.

RFID based People Management System

This is an internal application based on UHF (865 – 867 Mhz). The objectives of this project are:

- To monitor the movement of the people in the campus
- Assist in finding the location of the employee in the department
- Integrate with the access control system
- To develop software solution with various hardware makes and check the interoperability issues

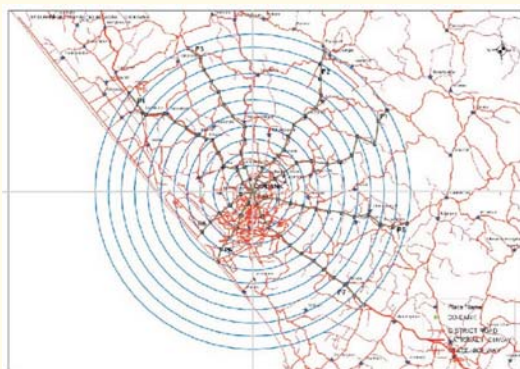
TETRA Based Systems

TETRA Radio Network for Kerala Police

This project aims at the development and customisation of TETRA system software for Kerala Police network and field verification of the same by porting it on to the hardware produced using C-DAC technology. The project will result in establishment of the first indigenously developed TETRA network covering Thiruvananthapuram city in Kerala.

C-DAC has now come out with a range of hardware and software modules for end-to-end solutions using the TETRA standard. The Kerala police has selected TETRA as the solution for their communication needs as part of the Police modernization scheme. The current project aims at establishing a Tetra network covering Thiruvananthapuram city.

The first indigenous, feature-rich, Tetra network using dual base station configuration, with IP linking between the two base stations, has been successfully installed in Thiruvananthapuram.



Base Band Embedded Software Solutions for TETRA

Both cost and size of a TETRA Mobile could be reduced significantly by eliminating two of the ICs invariably used in current designs.

This project aims to replace the digital blocks of TETRA Base band Processor (CMX 980) as software modules in "C", embedded in a programmable device like DSP. The project is planned in two phases. In Phase I, the complete digital blocks of the Base band processor will be developed as a software module and will be embedded in a DSP. In Phase II, the complete digital blocks of the Power Amplifier Lineariser will be developed as a software module and embedded in DSP. The Analog blocks will be separately realized using low cost, easily available, standard ICs like A/D converter or D/A converter. The proposed software would be developed in 'C' (and hence transportable to any DSP or programmable device). The development would be tailored so as to incorporate it with the existing design of Mobile or Base Stations with minimal changes. The specific technology fall out is that once it is demonstrated for TETRA standard, similar software modules could be developed for other mobile communication standards.

Tetra Communication System for Disaster Management

This project aims at technology development for a TETRA based communication system for disaster management that will come handy in events of natural calamities and during subsequent rescue operations. This project is planned for implementing in three phases. Phase 1 involves technology development, Phase 2 prototype fabrication and Phase 3 field trials.

This project will come out with a technology for a producible, quick field deployable system, which reduces time loss in deploying and restoring communication infrastructure, which is critical to life saving operations in such situations.

Electronic Nose, Electronic Tongue, and Electronic Vision Systems

Electronic Nose (e-Nose)

C-DAC has developed a special Electronic Nose that has been successfully used to monitor volatile emission pattern in black tea fermentation process over passage of time. Through prolonged experimentation with various clones, fermentation processes and climatic variations, it has been established that smell changes during the process may be reliably detected repeatedly by the Electronic Nose. Even the smell peaks during so-called “First Nose” and “Second Nose” may also be clearly detected with this new smart instrument.

The Electronic Nose is also capable of sensing the volatile compounds of the finished tea sample and reliably predicts Tea Taster like scores with a high degree of accuracy. Neural Network based Soft Computing Techniques are used to tune near accurate co-relation smell print of multi-sensor array with that of Tea Tasters' scores.

In a manner analogous to determining the quality of manufactured black tea, a method to determine the quality of cultivated aromatic cereals (e.g., Basmati) is being developed by C-DAC. Unlike the manufacturing of black tea, small growers cultivate aromatic cereals and that leads to possible adulteration with other similar-looking non-aromatic cereals. This challenges the sensitivity of the developed e-Nose to its limit. R&D level joint-participation from other Governmental Bodies (e.g., Indian Agricultural Research Organization (IARI) Pusa, New Delhi or Central Food Research Institute (CFRI), Mysore) are being sought for the requisite domain knowledge and/ or graded supply of samples.



E-Nose with illumination based heating

Electronic Tongue (e-Tongue)

Three out of ten quality of manufactured black tea comes from the liquor generated by tea in boiled water. With the sponsorship of the National Tea Research Foundation and Tea Board, e-Tongue Systems are being designed to measure these qualities in a physical manner to complement the measurement of other seven physical parameters of manufactured black tea with e-Nose and/ e-Vision for a complete physical measurement of manufactured black tea quality. The Instrumentation Department, Jadavpur University, Kolkata is a research partner to this e-Tongue Development Project.

Electronic Vision (e-Vision)

An Image processing based e-vision system has been developed to count the number of eggs laid by the Silk Cocoon producing Moth, and also to count the number of Micro-Spores that can only be seen under Microscope (with X600 Magnification) in the extracted body fluids of Moths that have already laid eggs.

Similarly, the developed e-Vision Software has been ported on Hand-held Mobile Handset (having built-in Camera) to estimate the quality of produce (e.g., Distribution of Black Tea Grains or Broken-count of milled Rice) on the fly in market conditions.



E-Vision for Basmati rice dimensionality characterization

Combined e-Nose and e-Vision Systems

Based on the successful demonstration of a laboratory prototype to the Tea Planters, the Tea Board has indicated their willingness to support production of field prototypes for a combined e-Nose/ e-Vision gadget to be sold to various Tea Planters under a suitably framed Memorandum of Understanding having requisite Non-Disclosure Clauses.

Other Technologies and Products

GPS Based Station Name Display System (SNDS)

The SNDS is a sophisticated, yet economical system that can display the station name inside the compartment and display the next stop in advance. The SNDS uses a Global positioning System (GPS) receiver to get the train's current position. The system is maintaining a database for the route and stops. The system can identify the stop automatically with respect to the GPS and display the station name on an LED display inside the compartment.

The local database is train specific and is maintained in a flash memory, which is non-volatile. The database consists of the station names where the train stops, their latitude and longitude. When the train begins the journey, the system identifies whether it is up or down journey and configures the route accordingly. The system is capable of displaying the Approaching Station name, Next Stopping Station Name, Leaving Station Name and the Left Station Name.

Smart Card System

This project is based on an idea conceived by C-DAC and executed with internal funding. Several Smart Card based products were developed and deployed internally (Smart Card Reader, Portable Smart Card Reader, Access Control System, Time Attendance System, Time Attendance and Access Control System), as part of proving and demonstrating this technology. The Access Control System and Time Attendance System have been deployed at the Pune centre of C-DAC as well as various other C-DAC centres across India.

The Attendance Management System at the Thiruvananthapuram centre of C-DAC is based on the Time Attendance System developed by C-DAC. Access Control Systems developed in-house have also been deployed in the various departments of Thiruvananthapuram centre. The fixed and portable Smart Card Readers are used for Canteen Management. Development of a modified version of Portable Smart Card Reader is in progress. All the other products are ready for technology transfer. Some external agencies have already shown interest in the ToT for these products.



Automatic Meter Reading System

The objective of this project is to design and develop an Automatic Meter Reading system, to effectively monitor and record the electrical energy consumption from the grid, in single phase domestic connections using Power Line Communication. Electrical utility companies world over are looking for ways to reduce the operating cost and thus improve efficiency. One of the ways to reduce operating cost is to implement the remote reading system by collecting the information from the meters through the power line. In such a system, a data concentrator is placed near the neighbourhood transformer, which collects the data from the electricity meters located in the houses connected to this transformer. The data is then transferred from the concentrator to the central office using the mid-voltage power grid, or telephone, or wireless link, etc. The system is also used for additional value added services like energy management and flexible tariffs.

The proposed Automatic Meter Reading system consists of Consumer Premises Equipment (CPE), Consumer Data Concentrator (CDC), Data Transfer Unit (DTU) and the Host Terminal (HT). The CPE is the energy-computing unit and is located at the consumer premises. The CDC will be located immediately after the distribution transformer. The CDC communicates with all the CPEs connected to it through the power line (using Power Line Modem integrated in both CPE and CDC) and collects the energy consumption details at periodic intervals. The CPE can be also used as a repeater for increasing the effective range of the system. The data stored in CDC is transferred to a DTU using a wireless link (IrDA or Bluetooth). The DTU collects data from several CDCs and transfers it to the HT located at the substation using USB/ Bluetooth.

The development and testing of CPE and DTU have been successfully completed, and mechanical design is in progress. Testing of CDC is in progress.

Biometric Identification System

Due to the permanence and uniqueness, fingerprints are the most reliable identification methodology extensively used around the world. The uniqueness of a fingerprint is specified by its ridge structure and the certain features of ridge topology termed as minutiae. A critical step in automatic fingerprint matching is to reliably extract minutiae from the input fingerprint images. However, the performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. In order to ensure robust performance of an automatic fingerprint identification/ verification system with respect to the quality of the fingerprint images, it is essential to incorporate a fingerprint enhancement algorithm also along with minutiae extraction. The scope of this project is to design necessary algorithm for finger print enhancement, extraction, identification and storing and implementation of the same on a hardware module as an “engine” for embedding into other applications. Application areas include Time Attendance, Access control, Identification card, Immigration checks, Police records etc. Detailed design of the Biometric Identification Module is in progress.

Medical Investigation Camera for Endoscopy

This project involves technology development of a miniaturized micro-electronic camera, which can ultimately be engineered in a capsule form, suitable for ingestion by patients. Being a highly complex blue-sky R&D, the first phase of the project seeks to develop the prototype electronics and software, as given below, engineered into a testable product.

A feasibility study would be carried out on the possibility of procuring and/ or developing the required components of the MICE. The most important component would be the miniature camera using CCD or CMOS technology as found appropriate, along with the associated instrumentation, especially the wireless transmission through the body tissue. A detailed study would also be carried out to identify the requirements of the image data logger used along with the camera. Studies would also be carried out on identifying candidate materials for the other components such as lens and enclosure. The choice of these materials for the enclosure is critical since they need to be biocompatible, with outside surface properties to prevent adhesion of biological fluids to their surface to preclude reduction in the quality of the image. A detailed Feasibility Study Report (FSR) listing out the technological alternatives for product development would be the intermediate milestone of this effort.

The next phase of the project will focus upon the development of the electronics subsystems using discrete electronics technology. The stress will be on miniaturization to the greatest extent possible, without incurring the high NRE costs of ASIC implementation. It will also address the highly critical issue of power consumption, since the operation will be from an integrated battery within the capsule, with very limited operating life. The mechanical aspects and fabrication of compact capsule-shaped housings using biocompatible materials and processes will also be tackled. The engineered MICE prototypes will be subjected to comprehensive pre-clinical trials on appropriate models, both in-vitro and in-vivo, and suitable mid-course corrections made if necessary. System study is in progress.

IP Set Top Box

C-DAC continuing its Research & Development initiative, took up the development of a Set Top Box with a view to providing the Indian Electronics Manufacturing market with high quality, low-cost IPSTB solutions. The present stage of development is uniquely poised as being in the forefront of STB technology development in the country. C-DAC is dealing with the complete range of technologies starting from Satellite (C and Ku Band), Cable, as well as Terrestrial solutions combining with IP Set top box solutions. The solutions are scalable and extensible as per the customer's needs. Full support is available at C-DAC for any upgradation, customisation, or development.

The need for Internet browsing was also envisaged and C-DAC has successfully integrated Oregon browser in the box that will help in the Internet penetration in the country.

The IP STB is based on a single chip solution from ST-Microelectronics and PHILIPS SEMICONDUCTORS. The full solution is based on Open source Linux environment.

Tamperproof and Secure Digital Courtroom Proceeding System

C-DAC has designed a tamperproof, secure and integrated Courtroom Recording and Video Conferencing system for digitally storing the courtroom proceedings and hearings along with the retrieval and authentication system for the original content. This solution facilitates the judge with discretion to allow for the photographing, electronic recording and television of court proceedings within the judicial network. The solution is an initiative taken towards the modernization of the judicial process. It also protects the anonymity of non-party witnesses by giving options in the system to have their voices and images obscured during testimony.

The system will be able to articulate all content associated with the captured event including audio, video, annotations and machine understandable data (metadata) as a single digital record.

The system will have graphical user interface detail to enable an operator to:

- View and monitor all the configured courtrooms.
- Read status indicator of courtroom recording activity.
- View live images of three and one remote camera on single display.
- Display on screen messaging including status, time and date stamp, and case identifier.

Applied Image Processing for Strategic Application

Keeping in view the public disclosure norms in the area of strategic applications, major activities in this specialized area is for Human Face Recognition; and in more advanced and exotic areas of Emotional Expression Recognition from analysing Human Faces.

For both of these applications, creating meticulously a calibrated Facial Database of reference faces constitutes an important enabling landmark. Even though humans recognize faces instinctively, to a camera (through which only computer can see), the human face is a 3-Dimensional object that has no intrinsic fixed aspect/ attitude. Moreover, the Facial Database must contain images of a number of human faces each having associated labels containing carefully measured/ categorized (a) emotion, (b) attitude, (c) aspect, and (d) intensity. Hence, a carefully designed infrastructure was designed for collecting calibrated images of human faces.

Sub-10K PC Phase I Part I

A proposal for Low cost PC was generated based on the suggestion put forth at an internal meeting for technology development/ reverse engineering of a standard IBM-PC compatible, with a price target of Rs.10,000/- in high-volumes. The proposed PC would be ported with Linux OS and an application suite enabling basic computing needs in English and Indian languages.

The project is proposed to be implemented in two-phases. Phase I envisages to procure subsystems and deploy 100K PCs. The detailed activities/ milestones which are envisaged are detailed study of existing models with particular regard to price, discussions with wide cross-section of potential targeted users in various sectors as above, feasibility study and detailed specification consolidation of the entry model PC and its proposed upgraded versions, design of country-specific and model-optimised hardware sub-systems such as cabinets and power supplies, negotiated procurement of 100K chipsets and motherboard designs with full application hand-holding by the CPU and chipset manufacturers, negotiating with various national and international suppliers for 100K volumes for optimised prices, consolidating the detailed application areas, and the requirements and specifications for software suites to be made available as total working solutions for home and office applications particularly for Indian language users and government, and identifying ToT partners to bring out "sub-10K" PC models and their enhanced versions to the market. Design of the Motherboard is in progress.

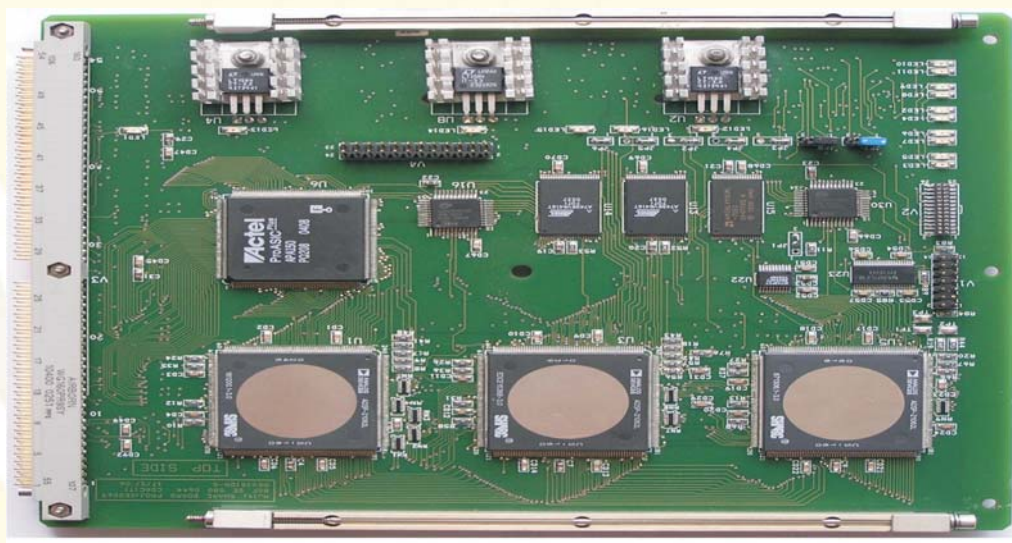
Signal Processing Engine with Embedded Digitisers

The objective of the project is to develop a Multi-Channel Signal Conditioning, Acquisition and Processing System using a cluster of Digitally Controlled Gain Blocks, ADCs, and DSPs. PCI Express, USB and Ethernet Interfaces will be provided. The system can be configured either as an ADD-ON Board, or as a stand-alone module. This will be a Data Acquisition and DSP Engine for many DSP based systems being developed in C-DAC.

Multi SHARC Boards

This board is used in the signal processing subsystem of the Advanced Experimental Torpedo (AET), developed by the Naval Science and Technology Lab (NSTL). Key features of the board include

- Cluster multiprocessing configuration with Five ADSP21062 Digital Signal Processors running at 40 Mhz Clock rate.
- 2 MB (2M x 8 bit) on board boot flash memory for application code
- 16 MB(8 Mx16 bit) On board data flash memory
- 512MB(128K x 32 bit) Onboard SRAM
- One16-bit Latched input/ output port with handshaking
- One 16-bit input port
- Two Serial PORTs (Synchronous) brought out to the edge connector.
- One serial port (Asynchronous) brought out to the connector. This can be configured as RS422 or RS232 by a jumper
- Inter processor communication through link ports, broadcast write, vector interrupts and message passing
- Semaphore and reflective semaphores for synchronizing tasks performed in multiprocessor system
- One link port brought out to edge connector for board to board communication
- 16-bit Data bus, 5 nos Output Enables, 5 nos Latch Enables brought to edge connector for I/O expansion off board
- Interrupt lines brought to the edge connector
- LEDs for status indication
- JTAG port for DSP board debugging and developing software
- Edge connections on 160 pin AIRBORN connector
- Board Dimensions:196 mm x169.75 mm x 16 mm (including height of components)
- Board weight (including all components and card guides): 400 grams max
- Power Supply: +5V
- Power Consumption: 6W maximum



Controller of Certifying Authorities (CCA)

The IT Act provides for the CCA to license and regulate the working of Certifying Authorities. The Certifying Authorities (CAs) issue digital signature certificates for electronic authentication of users. The CCA certifies the public keys of CAs using its own private key, which enables users in the cyberspace to verify that a licensed CA has issued a given certificate. For this purpose it operates, the Root Certifying Authority of India (RCAI). The CCA also maintains the National Repository of Digital Certificates (NRDC), which contains all the certificates issued by all the CAs in the country. C-DAC is actively maintaining the Disaster recovery site of the CCA.

Digital Programmable Hearing Aid (DPHA)

The DPHA is a low cost, highly featured programmable digital hearing aid using indigenously developed ASIC technology. Using sophisticated DSP techniques, the product offers superior and stable amplification characteristics over a wider dynamic range. The Digital Volume Control eliminates the crackling and popping noise characteristic of conventional hearing aids. Frequency dependent filtering finely matches the audiogram of the specific user, with the individual hearing losses over a period of time. All this high technology will be made available in a low-cost, low-power package, once the CMOS ASIC implementation is over.

Several prototype units of FPGA based DPHA have been fabricated tested successfully and sent to premier organizations in this area for field trials. The feedbacks obtained so far have been very encouraging. Discussions are going on with various foundries for fabricating the DPHA ASIC. ASIC fabrication will be done after consolidating the feedbacks from field trials.

RF Multi Carrier Power Amplifier for Advanced Wireless Base Station

Single carrier amplifiers and power combiners in Base Transceiver Stations are increasingly being replaced by single multi-carrier units that take up less space, consume less power, and cost less. The project scope covers the development of MCPA for low power applications, for a specified frequency band. The technology developed could later be extended to high power applications/ other frequency bands. The MCPA would be a component of Software Defined Radios (SDR). This project makes use of the latest DSP based design. The MCPA will have 4 channels for the 380-470 MHz band and will be scalable for all major modulations and mobile radio standards. One fully functional, 19" rack-mountable, MCPA prototype will be developed as a stand alone unit.

Audio Broadcast Monitoring System based on Watermarking

This project aims at the development of a system, including both hardware and software, for monitoring or recording the broadcast status of audio commercials or music programmes from an FM audio broadcast station, using watermarking technique.

The scope of the project includes the development of an algorithm for data embedding and extraction on MP3 compressed audio for streaming audio applications over Internet and mobile wireless networks.

Software Defined Radio

The objective of this project is to develop the technology required for a Software-Defined, re-configurable Radio, supporting multi-band and multi-standards, through a partnership between Sameer, Chennai and C-DAC, synergising the expertise available in these organizations and to come out with demo models of user-specific applications. The development will follow the SDR Forum Standards to ensure re-configurability and Safe Downloads from infrastructure. The models will be designed with scalability in mind and will support multi-band and multi-mode operation.

Metadata Embedding and Extraction on Digital Audio

Digital audio watermarking is the process of embedding perceptually transparent digital data in digital audio signals (host signal) to generate watermarked signal, in such a way that the embedded data doesn't interfere with the normal usage of the signal and can be effectively retrieved even after the watermarked signal is subjected to various signal processing operations, like filtering, time scale modifications, mp3 compression and decompression, D/A and A/D conversion etc., which doesn't effect the perceptual aspect of the signal. Digital audio watermarking can be performed using Metadata Embedding and Extraction on Audio ('MEEDA').

The developed software tool comprises two application programs - The Metadata Embedder and Metadata Extractor. These are stand-alone software applications that form a functionally complementing pair. The Metadata Embedder embeds a watermark into the given input audio signal, on the basis of a unique watermark key supplied by the user. The Metadata Extractor detects as well as extracts the watermark (if any) in the input audio signal, on the basis of a watermark key supplied by the user, which must be the same as the one used in embedding.

The above principle is used for developing a system for Audio Broadcast Monitoring. The system logs the timings of audio commercial broadcasts by decoding the identification codes embedded in the broadcast audio and has proven to be a cheaper alternative to the existing imported technology solutions. Copyright protection and owner identification are other applications of this technology.

Compact IP Telephone Module

The growing demand among communications providers and telephone subscribers for new generation of IP based services is now met by SIP – the Session Initiation Protocol. This IP-based voice communication system also enables conference calling, instant messaging, unified messaging and better mobility. SIP is the first protocol to enable multi-user sessions regardless of media content and is now a specification of the International Engineering Task Force (IETF).

The SIP Phone that has been developed is based on Texas Instruments' Communications Processor chip TNETV1055, which is a system-on-chip (SoC) solution for VoIP communication. The SoC solution has helped reduce the component count of the product significantly and has helped in bringing down the size and cost of the IP telephone to acceptable levels.

This product supports SIP protocol Ver 2 (RFC 3261), Speech Codecs (G.711, G.723A, G.729AB) and has facility for DTMF Tone generation, Acoustic echo removal, Voice activity detection, and Comfort noise insertion.

Integrated Automation of Tea Processing

Subsequent to the successful completion of the landmark project, warranty services are being provided to the Tocklai Experimental Station, Jorhat. The Model Tea Factory (MTF) constructed under the project is functioning to its laid down specifications and contributing to new knowledge discovery for Indian Tea Industries.

Setup of Specialized Research Laboratories

Auto ID Lab in India

Globally, there are seven Auto ID Labs, which are recognized as RFID excellence centres. They focus on formulation of new standards and development of new technologies, and identify organizations and industries working in the area of RFID and related technologies. Most of the labs have come up as self sustaining laboratories within the overall ambit of institutions such as; MIT, University of Cambridge, UK, ICU University, Japan, etc. except that of two institutions in Korea and China where the Govt. has facilitated and funded setting up of these laboratories.

For India to participate in the global movement of identification of merchandise and evolve applications meeting the Indian industry requirement, it is required to set up an Auto ID Laboratory in India to prepare its industry to participate in this movement. C-DAC has strongly focused in the creation of this lab and is active in RFID based applications development like File Tracking and Parcel Tracking System. The parcel tracking system improves the visibility of the parcel or the postal bag while they move from one post office to another. A successful pilot was done from Speed post centre New Delhi to Speed post centre Mumbai, using the postal network.

Network Simulation Lab

The licenses of simulation tools were renewed. The Lab was augmented with network emulation tools to work in conjunction with simulation for getting more realistic results, and emulations experiments with Qualnet are in progress.

Embedded Communications Lab

The objectives of this lab are:

- Investigations into flash memories and MTD subsystem under Linux
- Investigations into Flash file systems such as JFFS2 for embedded communication systems and its support under Linux
- Performance evaluation of JFFS2 and EXT3 file system using IOZone
- Investigations into cryptographic file system (Cryptfs) under Linux
- Investigations into BIOS and boot loaders for embedded Linux.
- Understanding and experiments with mechanisms to replace Linksys firmware with open source OPENWRT on Linksys WRT54G router
- Back-porting of Linux IDE device driver for Compact Flash from 2.4 kernel version to 2.2 kernel version
- Embedding of C-VPN on Soekris Engineering boards and performance evaluation
- Embedding of C-VPN on Routerboards from Microtik and performance evaluation

Wireless Sensor Network Lab

The objectives of this lab are:

- Identification of wireless sensor network hardware platforms and tools was done after interaction with research labs and academic institutions such as IISc Bangalore and IIT Mumbai
- Equipping wireless sensor network lab with hardware and software from Crossbow, USA. The hardware included wireless sensors (MTS300, MTS 310 and MTS420), motes (MICA2 and MicaZ – Zigbee motes) and gateways (MIB 510 serial gateway). The software includes TinyOS and Xbow applications such as Moteview, Surgeview, and TinyDB etc.
- Exposing members to Wireless sensor activities through workshops/ conferences and experiments
- Experimenting with Xbow applications and TinyOS to get a feel of working of sensor networks
- Understanding component architecture of TinyDB
- Switching among mint route protocol and reliable route protocol in TinyDB and Surge
- Modifying of TinyDB to make it work with MTS420 GPS sensors
- Tracking toy car with help of wireless sensors.

Wi-Fi Wireless Networking Lab

The objectives of this lab are:

- Modification of OLSR routing protocol to support client roaming/ mobility.
- Modification of OLSR routing protocol to support multiple interfaces.
- Design and implementation of software to modify routing rules to achieve channel diversity.
- Evaluation and procurement of Telelogic's protocol engineering tool viz. SDL and TTCN suite.
- Engineering auto-configuration protocol using Telelogic's SDL and TTCN industry standard protocol engineering suites.
- Simulations for determining co-relation between communication range, transmit power and antenna gain.
- Modification of OLSR simulation model in Qualnet to support multiple wireless interfaces.
- System level simulations of a wireless mesh networks to study mesh network performance over multiple hops.
- Comparative studies of various wireless routing metrics.
- Study of micro solar panels for wireless access points.

Cyber Security and Cyber Forensics

Cyber Forensics

Resource Centre for Cyber Forensics

A state-of-the-art resource centre for cyber forensics has been established within C-DAC for pursuing research and development, and for providing technical support and training to Law Enforcement Agencies of the country, in the area of cyber forensics. Activities of the centre include development of Cyber Forensics software tools for Disk Forensics, Network Forensics, Device Forensics, development of hardware tools for seizing and acquiring storage devices, SIM cards and Drive lock for different storage devices.

Achievements of this project include release of CyberCheck Suite V3.0 by Hon'ble Union Minister of Communications and Information Technology, Analysis of a number of cases referred by Kerala State Police as well as other Law Enforcement Agencies across the country and a number of training programmes on cyber forensics to officers of Intelligence Bureau, Forensics Science Laboratories, Army Cyber Security Establishment and Judicial Officers of New Delhi jurisdiction. Another notable achievement is the deployment of about 35 copies of indigenously developed suite of Cyber Forensics tools among various Law Enforcement Agencies of the country.

The resource centre has developed the following Cyber Forensics tools, which have been made commercially available:

- TrueBack: Disk Imaging tool
- CyberCheck: Data Recovery and Analysis tool
- EmailTracer: Tool for tracing sender of an e-mail
- Hasher: Tool for verifying integrity of files
- PDA Analyser: for analysing Personal Digital Assistants
- Log Analyser: Tool for analysing different logs
- Voice and Data Session Analyser: Tool for analysing and reconstructing sessions

CyberCheck Suite

Following tools have been bundled and released as CyberCheck Suite for helping Law Enforcement Agencies.

TrueBack	- Disk imaging tool
CyberCheck	- Data recovery and analysis tool
EmailTracer	- Tool for tracing sender of an e-mail
Hasher	- Tool for verifying integrity of a file



Cyber Crime Awareness and Prevention Programme

Kerala State IT Mission has launched a scheme called 'Cyber Crimes: Detection, prevention, and awareness building Programmes' in collaboration with the Resource Centre for Cyber Forensics, C-DAC to achieve the following objectives:

- Increase in Awareness Against Cyber Crimes
- Increase in the Usage of Cyber Crime Prevention methodologies
- Increase in Usage of Digital Signature
- Increase in Usage of Parenting Software
- Proper Guidance to the Common Man

Major activities in this programme are:

- One Day awareness Programme for Govt. Officials
- Equipping Akshaya Centres and Police to Handle Cyber Crimes
- Development of Cyber Crimes Portal and Call Centre

Intrusion Detection and Response Systems

Attack Methodology Analysis, Network Attack Modelling, and Survivability Simulation

As a part of Department of Information Technology, Ministry of Communications and Information Technology, Govt. of India funded project, C-DAC has developed core competence in Honeynet technologies, for intrusion detection and analysis, which will be deployed for the Indian cyber space.

Attack Tree Generation for Improved Intrusion Response

C-DAC has developed a detection software for multistage attacks through attack modelling. The software aims at intrusion visualization through attack tree generation. Further research is being carried out to develop a system for intrusion response.

C-DAC has also developed expertise in generation of IDS evasion attacks and its detection scripts.

Performance Improvement of N@G

N@G is an Intrusion Detection System (IDS) developed by C-DAC. As processing power and memory availability are increasing continuously, C-DAC is designing a new structure for in-memory rules, to handle the 6000+ IDS rules efficiently.

Other Initiatives in Information Security

End System Security Solution

C-DAC has completed the “Design and Development of an End System Security Solution for UDP Applications” during November 2006. This is an R&D project funded by the Department of Information Technology, Government of India. This project involved development of a transparent security solution for all UDP applications. Security requirements of both unicast and multicast applications are addressed in this solution. The salient features of this solution are confidentiality and integrity for UDP datagram communication, authentication of peer (client/ server or sender/ receiver) machines using the signature generated from various hardware and software parameters, pluggable user authentication interface, role based network access control and support for datagram reliability using forward error correction technique.

This solution has been implemented for both Windows and Linux environments. Earlier C-DAC had developed the transparent security solution for TCP applications, which has been integrated with the UDP security solution. This solution is titled as End System Suraksha Framework (EnSAFE). The present focus is on commercialising the security solution for possible business opportunities.

Face Identification Software

The scope of the project is to develop a complete face identification/recognition system and creation of facial database covering different ethnic groups of Indian population. The final face recognition software is proposed to have three hierarchical stages of recognition. The first level of recognition is based on Principal Component Analysis (PCA) and has already been realized. Development of two more modules for biometric feature-based recognition are presently going on.

Cryptanalysis: Algorithms and High Performance Computing Techniques

The principal objective of the project is to study the wide range of cryptanalytic algorithms and related techniques/ concepts, and exploit the massive computational power of high performance computers for efficient implementation. PARAM Padma is being used extensively for developing and testing parallel code for various cryptanalysis algorithms. Few modules of cryptanalysis algorithms have been implemented in reconfigurable hardware for performance acceleration.

Extending Security Enhanced Linux to Support Resource Usage Policies

C-DAC is extending SELinux to support resource usage policies using the security contexts provided by SELinux to uniquely identify the kernel objects. SELinux provides support for Mandatory Access Control (MAC) policies in an operating system.

Information Security Awareness Initiatives

Information Security Education Awareness (ISEA) Programme

Under the Master Trainers Programme of ISEA, members of C-DAC were trained at TIFR, IISC, CMU-USA as Master Trainers in the area of Information Security. Following this, C-DAC has trained and is actively training government officers in Information Security. The Hyderabad centre has been given a major responsibility to implement a mass awareness programme for Information Security catering to school children, teachers, housewives, etc. This requires establishment of an ISEA portal, implementation of awareness training material, development of security toolkit, etc.

C-DAC actively participated in the syllabus preparation of Information Security education for different courses being offered under the Information Security Education Awareness (ISEA) programme of the DIT. As a participating institute under the ISEA programme, a one-semester certificate course is being offered on Networking and System Security (CNSS). This course is specifically designed to meet the needs of networks and systems administrators in Information Security.

Website and Courseware for Training on Information Security

C-DAC has bagged a new project for the design and development of a website and courseware for training of Government Officers on Information Security. The objectives of the project are design, development and maintenance of a dedicated website on Information Security Education and Awareness, design and development of modular courseware on Information Security for short duration and converting the above training programs for dissemination through e-Learning.

Health Informatics

Telemedicine Solutions

Telemedicine and Tele-education Facilities in Kerala

C-DAC implemented this project with the aim to setup identified Tele Health Services in the State of Kerala viz., Tele-Consultation and Tele-Education for Continuing Medical Education (CME).

The five referral Telemedicine Centres which are Taluk Hospitals in Kerala (Quilandy, Vythiri, Mavelikkara, Neyyattinkara and Mental Hospital Thiruvananthapuram) have been connected to the Specialty hospitals (Medical College Hospital, Sree Chithira Thirunal Institute and Regional Cancer Centre, Thiruvananthapuram) through ISDN dial-up connection and C-DAC's Mercury telemedicine software has been deployed at each centre for creating and transferring consolidated Electronic Medical Record (EMR) from various sources like ECG, Microscope, Scanner, etc.

The facility was inaugurated by Sri.V.S. Achuthanandan, Hon'ble Chief Minister of Kerala on March 16, 2007. Through this project, a high performance Video Conferencing System and online interaction facility between patient end and specialist end with Tele Health Services is established and also continuing medical education programs is provided at the Taluk hospitals, in coordination with the Clinical Resources from the identified Referral Hospitals.

Mercury™, C-DAC's Integrated Telemedicine Solution deployed under the project has been developed by C-DAC under a DIT funded project.



Mercury – C-DAC's Integrated Telemedicine Solution

Telemedicine Facilities in Tamil Nadu

The project is funded jointly by the DIT, MCIT, and by the State Govt. of Tamil Nadu. C-DAC and the DCL Software Limited, Chennai are jointly implementing it.

The objective of the project is to setup identified Tele-Health Services in the State of Tamil Nadu viz, Tele-Consultation. Although not a deliverable, it will provide a technological platform tuned for Continuing Medical Education (CME) to sites in the project.

The Govt. Royapettah Hospital, Chennai is the Telemedicine Referral Center (TRC) under the project. Apart from core telemedicine platform, the web-based access system will also be implemented at the site. The TRC under the project will provide remote specialist support to RTCs.

The Remote Telemedicine Centres (RTCs) will be built at Government Head Quarter Hospitals at Tiruvallur, Kancheepuram, Tiruvannamalai, Krishnagiri, Ooty, and Rameshwaram. Site infrastructure building at these sites is under progress. These RTCs will be equipped with Clinical Equipment like ECG Machines apart from telemedicine platform.

Mercury™, C-DAC's Integrated Telemedicine Solution deployed under the project has been developed by C-DAC under a DIT funded project.

Telemedicine Facilities in Two States in North-East India

C-DAC successfully completed the project for setting up of Telemedicine facilities in two states of North-East India. The two North-East states in which telemedicine facilities were set up are Sikkim and Mizoram. C-DAC and Apollo Telemedicine Networking Foundation (ATNF) jointly implemented this project.

Mercury™, C-DAC's Integrated Telemedicine Solution deployed under the project has been developed by C-DAC under a DIT funded project.

Telemedicine Service between Government Hospital, Raibareli and SGPGIMS, Lucknow

C-DAC was awarded the work order to setup Telemedicine service between Government Hospital, Raibareli and SGPGIMS, Lucknow under the GAIL CSR Program.

Under the project, C-DAC has provided and deployed complete telemedicine platform including hardware and telemedicine software. C-DAC has also trained site staff to operate the solution provided. SGPGIMS is providing specialist support to Government Hospital, Raibareli.

Mercury™, C-DAC's Integrated Telemedicine Solution deployed under the project has been developed by C-DAC under a DIT funded project.

Telemedicine Facilities in Ethiopia

C-DAC was awarded the work order to provide Mercury™, C-DAC's Integrated Telemedicine Solution and training for deployment of telemedicine services at Ethiopia and India under Ethiopia e-Network pilot project.

Telecommunications Consultants India Ltd (TCIL) is the nodal agency in the Pilot Project. The project aims to share expertise of Indian medical professional with that of Ethiopia. This pilot project is a precursor to PAN-Africa e-Network Project catering to 53 countries under African Union with telemedicine and tele-education services. The Ministry of External Affairs, India is funding the project.

Under the project, a Remote Telemedicine Centre (RTC) in Nekempte, Ethiopia has been setup. A patient-centre cum primary-Telemedicine Referral Centre (RTC, pTRC) at Black Lion Hospital, Addis-Ababa, Ethiopia is operational and providing specialist support to RTC in the project. At India, secondary-Telemedicine Referral Centre (sTRC) is operational at Care Hospital, Hyderabad, India and providing specialist support to both hospitals in Ethiopia.

Telemedicine Facilities in Himachal Pradesh

The project is funded jointly by Department of Information Technology, Ministry of Communications and Information Technology, Govt. of India and Himachal Pradesh Health and Family Welfare Department.

The project was extended by 6 months on account of delay in implementation at some of the remote locations due to extreme weather conditions.

The aim is to connect 21 locations of Himachal Pradesh through ICT and run Telemedicine application software Sanjeevani which is an integrated telemedicine solution based on 'Store and Forward' concept of telemedicine where the consulting professional reviews data asynchronous with its collection. The programs employ transmission capabilities, 'store and forward' as well as 'real time transmission' to maximize efficient use of resources appropriate to the medical services being provided. This interactive tele-video transmission happens via personal computers and remote monitoring.

Out of the 21 RTCs, 12 sites are fully functional and regular sessions are being carried out to benefit patients from the setup.

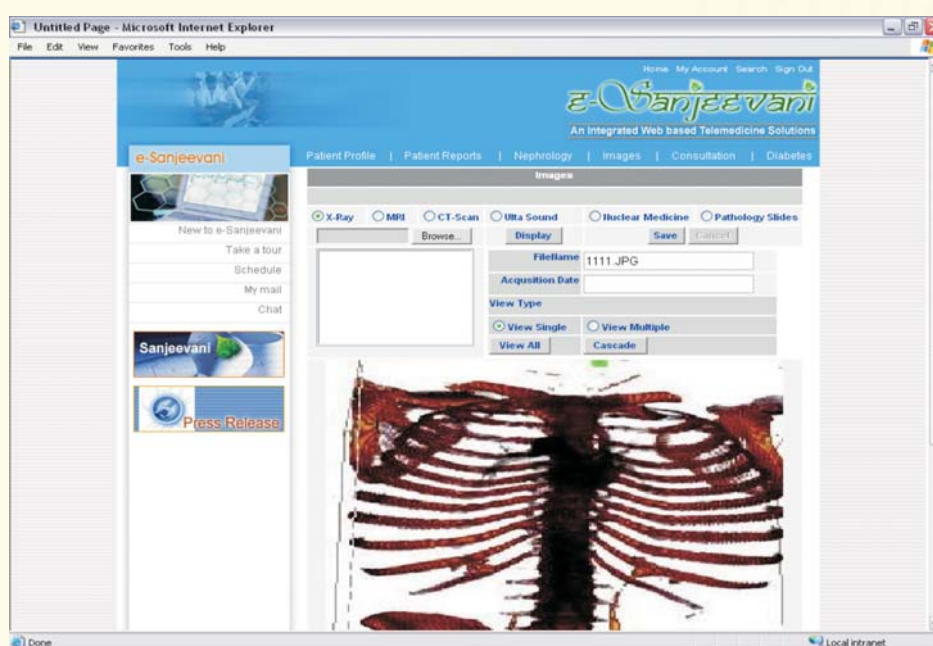
The Telemedicine Referral Centre (TRC) IGMCI Shimla is presently sending expert opinions to all the working sites and daily two-hour session is organized throughout Himachal Pradesh with the help of local doctors and technicians.

Telemedicine Facilities in Punjab

The project is funded jointly by the Department of Information Technology, Ministry of Communication and Information Technology, Govt. of India and Punjab Health System Corporation.

The aim of the project is to develop and implement the customized Telemedicine Application for the rural and remote areas of Punjab at 20 different locations. PGIMER Chandigarh and PHSC Mohali are the TRCs and all the 17 districts are being setup as the RTCs. Also, three medical colleges namely Rajendra Hospital Patiala, Faridkot Medical College and Amritsar Medical College will also provide expert consultation through the use of e-Sanjeevani application software which allows healthcare professionals to perform live and interactive medical examinations on patients in remote locations.

Out of the 17 RTCs, 3 are already setup and fully operational. These RTCs are well equipped with Clinical equipment like ECG machines, Tele-pathology microscopes, BP meter, Glucometer etc.



e-Sanjeevani

Tele-ophthalmology Solution for Punjab

The aim of the project is to connect 100 Villages in District Ropar through the use of interactive communication technologies, which allow people in different locations to meet for a range of clinical applications within the health field of eye care. The project will provide access to Eye Care specialty services to patients in rural and remote areas by reducing the travel cost and time for patients by means of Tele-Ophthalmology Mobile Van, also, to provide disease screening, diagnosis, monitoring, and management, etc. to the patients who are unable to avail the services of an ophthalmologist. The aim was to develop low cost, easily adaptable software for Tele-ophthalmology as a part of Sanjeevani Telemedicine software, which can improve quality access and quality of health service to the rural population. The project seeks to generate awareness about eye disorders and its complications to the general population in rural areas.

Web Based Imaging System and Telemedicine Network for Cancer Institute (WIA), Adyar

The project aims to setup a telemedicine hub at CIWIA and connect it to seven remote centres. These centres will be used primarily for early cancer detection and follow-up treatment. It can also be used for creating cancer awareness, training, and Continuing Medical Education. Early cancer detection centres will have Tele-pathology and Tele-radiology support. For image capture, storage,

transmission, and remote viewing, C-DAC's Mercury telemedicine software is being used. For obtaining expert opinion, these images have to be made available ideally over a Web interface. This enhancement will be part of the project.

CIWIA is spread over two different campuses. Network connectivity needs to be established between the two campuses. Establishing this high bandwidth Internet connectivity is also a part of this project.



*Video conferencing between Adyar Cancer Institute and
Telemedicine Lab at C-DAC, Thiruvananthapuram*

Rural Healthcare Delivery System through Telemedicine

The core objective of the project is to develop and pilot implement a resources sharing, integrated, rural healthcare delivery system through Telemedicine using Information and Communication Technology (ICT) at Tirur Taluk of Malappuram District in Kerala, using available network coverage provided by Akshaya network. This will facilitate some of the selected Primary Health Centres, Community Health Centres, Block Panchayath Health Centres, Taluk Hospital, and District Hospital to have expert consultation with the Specialty hospitals like Regional Cancer Centre, Medical College Hospital, and Sree Chitra Tirunal Hospital at Thiruvananthapuram and the Medical College Hospital at Kozhikode. Also, this will allow the rural hospitals to attend appropriate CME programs hosted at the Specialty hospitals. The system will be using low cost equipments and telemedicine software.

Low Cost Mobile Telemedicine Facility

Mobile tele-clinical van with necessary medical equipment goes in regular interval to the rural areas on a pre-specified schedule. The specialist doctors will be available in the hospital. Patients come to the mobile van for consultation. If expert consultation is required, a video conferencing session is initiated between the van and the hospital. Patients' diagnostic and treatment details such as medical images, records, outputs from medical devices are also sent online to the hospital thru 802.11g wireless links. The specialist doctor(s) study the medical history/ record of the patient. After diagnosis, doctors decide the treatment.

Health Management Information Systems

Kerala Health Management Information System - Phase II

C-DAC was engaged by the Sector Reforms Cell of the Directorate of Health Services, Department of Health, Govt. of Kerala to prepare a Master Plan for setting up a Health Management Information System (HMIS) for the state of Kerala, with funding from the European Commission. Accordingly, C-DAC conducted a study of the Organizational Structure, Services Offered, Information requirements, Data Collection process, Reporting process, and the existing software. C-DAC submitted a Master Plan based on this for setting up a Health Information Infrastructure, with recommendations on Architecture, Hardware, Software, Connectivity, and

Data Entry models, making use of available infrastructure in the Department as well as the State. Setting up a centralized HMIS will enable collection and dissemination of all the data in the quickest possible time. The goal can be achieved in a phased manner starting with the Directorate and DMOs initially and then extending the network to BPHCs/ CHCs and then to PHCs. Gradually this can be extended to sub-centres, and then to the field through handheld portable devices.

Linking District Medical Offices in Kerala

The project Kerala Health Management Information System - Phase II is towards the implementation of the first phase of the recommendation made in the master plan for HMIS. This project comprises the development of an integrated HMIS with Disease Surveillance capability for the Directorate of Health Services by linking all District Medical Offices (DMOs) in the State. The application is hosted in a central server, and necessary infrastructure is setup at the Directorate of Health Services (DHS) and the DMOs under the DHS for Health related Data Entry and Reporting.

The Health Programme module facilitates the data collection and reporting functions of HMIS. Data entry and report generation for various health programmes like the Family Welfare Programme, National Blindness Control Programme, Community Needs Assessment Approach Forms, and Disease Surveillance etc. is possible.

This project also includes the development and implementation of an Administrative Application suite comprising of various modules for handling Institution Infrastructure, Budget Monitoring and Control, Employee Records, File Flow Management etc. Each module has been developed in such a way that it can be extended to any institution, which can establish a connection with the central database. The development of Health Management Information System as a browser-based application hosted at a central location makes the data entry possible from any point of service.

Consolidation of data and generation of reports is possible at any level without any additional data entry. Different report templates provided by the application makes the report generation easy. The system is capable of providing accurate, relevant, and up-to-date information on all Health related activities for taking decisions that would improve service delivery.

The application modules are developed as JAVA based web-oriented application developed using J2EE with Struts framework and ORACLE 10g Database. The application is deployed using Oracle 10g Application Server. The applications developed can be replicated by the Health Departments of other states for implementing state-wide Health Management Information System with minimum customisation.

Rural Health Management Information System

The objective of the project is to develop a resources sharing, Rural Health Management and Information Infrastructure using ICT and demonstrate the working of such a network in a typical rural taluk, so that the impact can be assessed in an objective, scientific and convincing fashion. The product is a state-of-the-art Health Management Information System that is capable of providing accurate, relevant and up-to-date information on health related activities in the Public Health Care system. This project is for extending the Health Management Information System to BPHCs/ CHCs/ PHCs and then to Sub centres, and ultimately to the fieldworkers using handheld devices. The pilot implementation will be carried out at Tirur Taluk of Malappuram District, Kerala.

A central Health Information Server for HMIS at eGovernance Data Centre will be setup. All the BPHCs/ CHCs and PHCs of Tirur Taluk will be connected to the central server using Kerala State Wide Area Network. The health workers of the sub-centre will be equipped with handheld devices, which will be used, for data collection from the household and various reports can be generated using this raw data.

The project involves the development of handheld device application software for data collection from the field and also an integrated HMIS Application. The handheld device application is being developed using J2ME technology and Mimer SQL database. HP IPAQ

Pocket PC Series will be used as the handheld portable device. An integrated HMIS with an open source solution based on PostgreSQL database, which is capable of handling various National as well as State level health programmes, will also be developed.

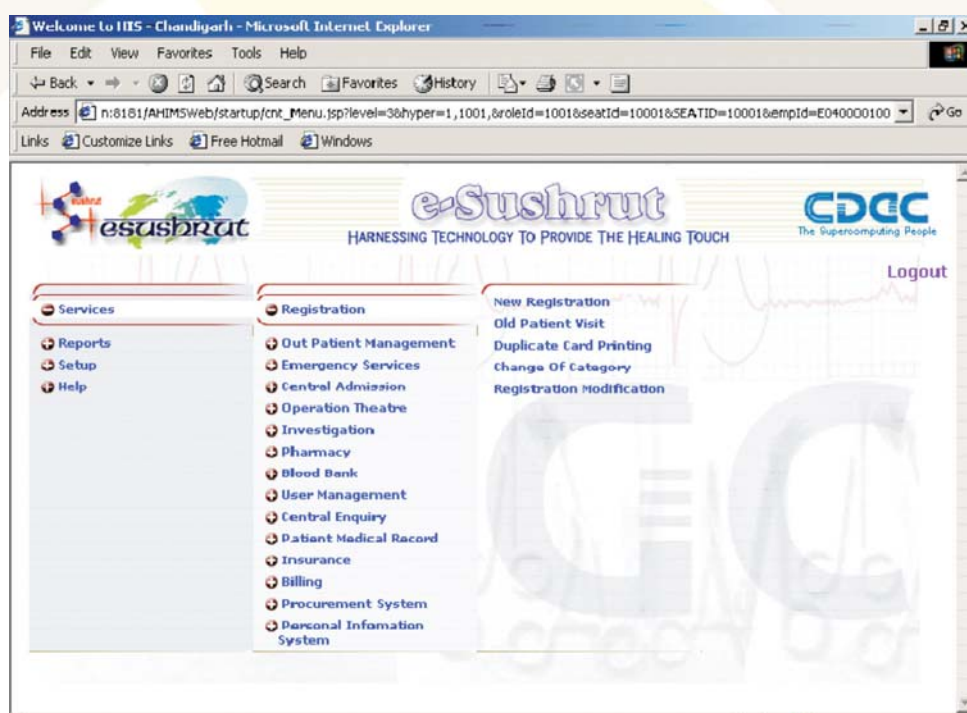
The system helps to maintain an electronic medical record of a patient. A replicable and scalable model for rural HMIS is expected to be evolved. Data collection using handheld devices can increase the efficiency of health status monitoring and the speed at which disease outbreaks can be handled.

e-Sushrut – Hospital Information Management System (HMIS)

C-DAC has developed e-Sushrut, a HIMS, to streamline the treatment flow of a patient within the hospital, besides helping to enhance the efficiencies of doctors, paramedics and other staff. e-Sushrut is built on a framework that covers the following areas:

- **Clinical Services:** Front Office, Registration, Emergency, Central Admission, Patient Routing, Appointment and Scheduling, Lab Services, Out Patient Management, In Patient Management, OT, Surgery Scheduling, Pharmacy, Blood Bank, Diet and Kitchen, CSSD.
- **Support Services:** General patient enquiry, Linen, Sanitation, Security, Transport, Bio-Medical waste management
- **Back Office Services:** Administration, Human Resource Management, Stores, Inventory, Purchases, Library Management, Billing, Financial Accounting System and Maintenance (equipment/ infrastructure)
- **Man-Machine Interface Services:** Bio-medical equipments, Barcode devices, Bio-metric devices, mobile computing, smart-tags, Telephony devices and IVRS.

C-DAC continues to customize and deploy e-Sushrut in various different healthcare centres in the country. During the year, it deployed e-Sushrut at Mahatma Gandhi Institute of Medical Science (MGIMS), Sevagram. C-DAC is also working towards porting e-Sushrut on multiple platforms such as Web-logic Web-sphere application server and Firefox/ Mozilla browser on Linux platform.



Computerization of Health Care Centres

Computerization of Medical College Hospital, Trivandrum

The software has been developed as a 3-Tier Application using Java, based on Model View Controller (MVC) Architecture, over Oracle 10g Database. The Database and Application Servers are hosted in the Linux Enterprise Server OS. The 250 node campus wide network is with fibre optic link and connectivity to the e-Governance Data Centre.

The OP Management *module* handles the Out Patient Registration and Token management, Queue management, statistical report generation, etc. The IP Management *module* handles the Admission of In Patients with operations like entry of demographic data, Referral details entry, IP number resetting, etc.

The Ward Management module handles management of IP related operations like maintenance of Patient Records, Bed Transfer, Investigation Requisitioning, Case sheet maintenance, Discharge Reports, Diet sheet, etc. The Lab Management module handles the Administrative functions in the Diagnostic centre like Test Requisitioning, Result entry and Report printout. The Resource Scheduling module handles Scheduling of Resources in the hospital like Theatres and Equipment.

The Enquiry Module handles information management like IP whereabouts of patients, pay ward booking status, Doctors' availability and lab results enquiry.

As part of the computerization, 80 Computers, 80 Printers, 2 Servers, one Layer-3 managed core switch, 13 Layer-2 managed edge switches and Network Management Software were supplied. Token Display System for Queue management is utilised in 10 OP Clinics. Software application is functional in 35 wards, 9 ICUs, 5 Operation theatres, 10 Labs, 9 OP Counters, Casualty, IP admission counter, etc.

Cosmopolitan Hospital Computerization in Kerala

The Front Office module handles Patient Registration, Consultation Management, Admission, Discharge, Bill Payments, all Cash transactions and Enquiries. The Pharmacy module handles Billing and Inventory management in Pharmacy and other medical stores in the Hospital. The Lab module handles the Administrative functions in a Diagnostic centre right from Test Requisitioning to Billing, Result entry and Report printout. The IP Billing module handles activities of the Billing section like Posting of Vouchers, Preparation of Intermediate/ Final Bills, Generation of Income Analysis statements, etc. The Bills Receivable module handles generation and settlement of claims for organizations availing credit, settlement of outstanding bills and advances, etc. The Ward module handles management of IP related operations like Investigation Requisitioning, Case sheet maintenance, Drug Administration, Diet requisitioning, etc. The Stores module handles the Inventory Management activities of the Central Stores in the Hospital like Purchase, Issue, Reordering, etc. The Canteen module handles Canteen Billing and Kitchen management. The Operation Theatre module handles Scheduling of Surgery appointments, Theatre Diagnosis and Operation Summary entry, Indent generation, etc. The Financial Accounting Module automates the accounting operations and interfaces with the other modules of the system for automatic posting of transactions. The system has also been interfaced to the Tally Accounting Package. The MIS Module is intended to provide the information required by the top management from the Hospital Database for information and planning purposes. The DBA Module provides facilities for maintenance of the master data and business rules of the hospital, creating users and user groups, defining roles, and managing user privileges. The Database is deployed on Oracle Server over Windows 2000 operating system installed on midrange HP server.

Computerization of Health Directorates in Kerala

All the five Directorates under the Department of Health – Directorate of Health Services, Directorate of Medical Education, Directorate of Homoeopathy, Directorate of Indian Systems of Medicine and Directorate of Ayurveda Medical Education - have been computerized

by setting up high performance servers, terminals, intranets etc. Office Administrative application suite comprising of Institution Infrastructure Management, Budget Monitoring and Control, File Tracking, Employee Records Management and Office MIS module is also deployed. The system is capable of providing accurate, relevant and up-to-date information on Institution infrastructure, vacancy positions, budget provision, utilization and allocation expenditure balance, File status, Pending Files etc.

The software development for this project has been done keeping in view the requirements for extending the system to other lower level institutions. The application has been developed as a three-tier system, based on the MVC architecture. The implementation has been done using Java Beans, JSPs and Servlets. Apache Tomcat has been used as the Application Server, and Oracle 9i as Database server. The Database and Application Servers have been hosted on Linux Enterprise Server OS.

Other Healthcare Initiatives

AyuSoft

The development and field trials of AyuSoft (A decision support system based on Ayurveda) was completed and it was released in November 2006. The software received an overwhelming response from Ayurvedic physicians, researchers, industry and the academic community. AyuSoft was appreciated at various national and international events including World Ayurveda Congress 2006, Ayurveda Update and 3rd Nutraceutical Summit.

Presently this software has been marketed and used as a base in some research projects. In view of the wide utility of this novel system, it has received an offer to join 'Global Information Hub on Integrative Medicine', an initiative of 54 Commonwealth countries.

C-DAC along with the Department of AYUSH and the Central Council for Research in Ayurveda and Siddha (Ministry of Health and Family Welfare) are engaged in further propagation of this software.

Class Libraries for DICOM and HL7

The project is funded by the DIT, MCIT towards building indigenous standard protocol implementation.

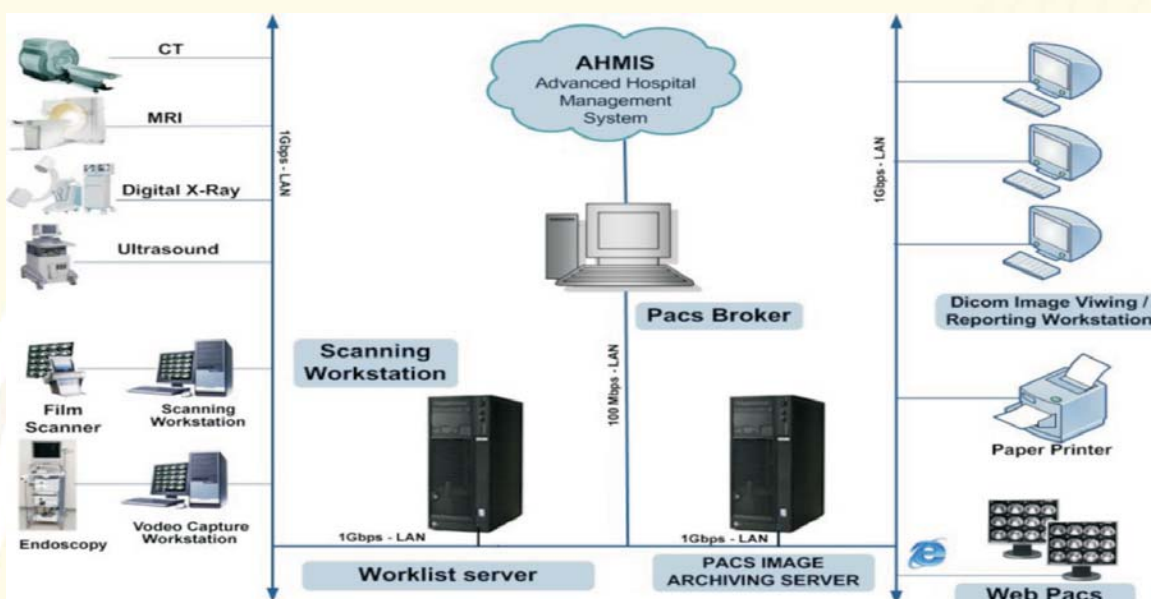
The objective of this project is to design and develop components that can be used to build class libraries/ SDK/ API/ Toolkit, which in turn can be used to incorporate Digital Imaging and Communications in Medicine (DICOM) and Health Level 7 (HL7) support in end user applications in the area of Medical Informatics.

The components will be adhering to the standard and would provide functions/ services as mandated in NEMA's DICOM v3-2004 standard and ANSI approved HL7 v2.5 standard.

The aim of the project is to not only make low-cost SDK available but also enable medical device and application manufacturers to become standards compliant. The SDK will add innovative programmability options for standards incorporation in medical application and equipment.

e-Chhavi – Picture Archival and Communication System (PACS)

C-DAC has developed e-Chhavi, a Picture Archival and Communication Systems which enables automated work flow, rapid enterprise-wide image distribution, long-term archival and retrieval of images and for improved image interpretation by a specialist. Besides Radiology, these systems are employed in Laboratory automation and image processing applications using filtering and analysis techniques for cell and biomaterial quantification, and qualification. PC based vision systems offer increased productivity, flexibility, consistency, reliability, higher throughputs, and the capability to perform more complex inspection tasks.



ONCONET INDIA

Cancer is a major public health problem in India, today. The tremendous success of ONCONET-Kerala, a pioneering effort to provide tele-consultation facility for cancer patients, made by C-DAC in association with DIT and Regional Cancer Centre, Thiruvananthapuram, has been well appreciated by Ministry of Health and Family Welfare (MOHFW), Government of India. Based on this, MoHFW approved a project proposal for implementing “ONCONET India”, an effort to replicate the system so that the benefits of the telemedicine initiatives would reach all other parts of our country. A detailed Project Report for this project has already been submitted by C-DAC. The following objectives have been envisaged under ONCONET-India project:

- Establish knowledge enabled Oncology network through computer connectivity among the 25 RCCs and 100 remote site hospitals in India and provide telemedicine services in the early detection, treatment, and follow up consultation of Cancer.
- Promote cancer awareness among the people through the network
- Provide Tele-education
- Provide a platform for surveillance and analysis of data and for uniform reporting about cancer pattern of the entire country.

In this proposed method, all the twenty-five regional cancer centres will be connected to its remote site hospitals with high bandwidth 384 kbps VSAT connectivity from ISRO and also with uninterrupted high bandwidth terrestrial Broadband Virtual Private Network (VPN) connectivity of 512 Kbps from Bharat Sanchar Nigam Ltd.

Electronic Medical Record (EMR) System for Ophthalmology

The EMR Solution for Ophthalmology is an open source system that helps to maintain patients' records electronically. The main users of the system are Doctors, Refractionists, Laboratory, Pharmacy, Personal Counselling section, Patient Registration counter, and Optical centre. Each group of users has their own access privilege. The various functional modules of the system correspond to the user categories. The solution is provided as a web based application. The system can be easily customized for any Eye hospital/ clinic.

The major modules of the system are Patient Registration Module, Refraction Module for entering information about refraction tests, Doctor's Module and Personal Counselling/ Report Generation Module. The Doctor's module helps doctors to enter patient's

medical history/ diagnosis/ advice/ etc. This module also supports image drawing capability to record some of the observations with the help of an image and helps doctors to prescribe medicines/ eye-glass and this record will be visible at the pharmacy and optical centre of the hospital. In addition, doctors can also navigate through patient's previous records (if he is a follow-up patient) and the various test results. The Personal Counselling/ Report Generation module helps to build a consolidated case sheet; including prescriptions, corresponding to a particular consultation.

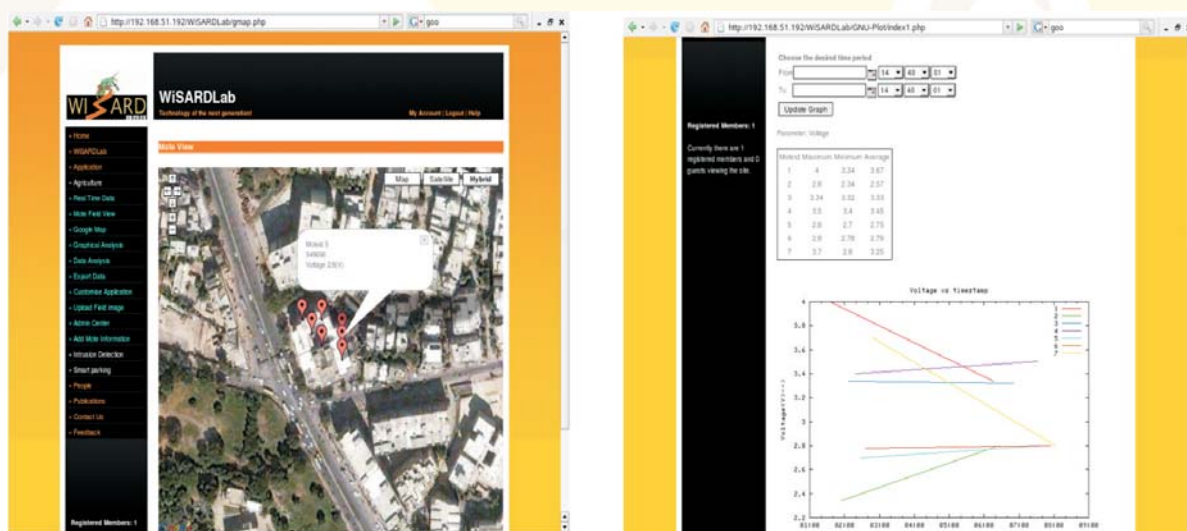
Instrumentation assisted Decision Support System deploying Data Mining Techniques for Pulse Examination and Diagnostics (Nadi Pariksha)

The DIT has recently awarded a new project "Instrumentation assisted Decision Support System deploying Data Mining Techniques for Pulse Examination and Diagnostics (Nadi Pariksha)" to C-DAC for research and development of a Pulse Analysis tool. Pulse analysis is a diagnostic examination based on Ayurveda and this project aims at research on development of an intelligent instrument to diagnose some of the pulse related characters. Bhabha Atomic Research Centre and Indian Institute of Technology, Mumbai are other collaborating institutes for this project.

Ubiquitous Computing

C-DAC is working on a project to develop a co-ordination and context-aware middleware for ubiquitous computing using Ubiquitous Semantic Space and Ontology based Context Aware Environment for ubiquitous computing.

As part of the ubiquitous computing activities, C-DAC has established a concept-proving laboratory for carrying out Wireless Sensor Network Applications Research and Development (WiSARD Lab). The WiSARD Lab consists of various hardware equipment like Wireless Sensor Nodes, Base station, WLAN, GSM/ GPRS, Bluetooth, and versatile software tools including TinyOS, NetBeans 5.5, OMNET++, Ptolemy-II, TOSSIM, SPIN, etc. C-DAC has conducted a survey of various simulation tools for WSN. A detailed technical document on System Requirement Specification (SRS) related to Host subsystem and WSN Subsystem has been prepared. Various Routing and Dissemination protocols have been analysed, customised and designed towards the specific need of the system. Design documents specific to each unit of Localization, Routing, Dissemination and Transmission Packet Optimiser along with Host Subsystem have been made to further carry on the project development phase. A Generic Web based Host Side GUI Interface for Wireless Sensor Network applications has been designed and developed. The system has been provided with a flexible interactive environment by integrating it with GSM, WLAN, Bluetooth and speech recognition system.



Education and Training

C-DAC continued its foray in education and training through its several formal and non-formal training programmes with the objective of sharing the knowledge generated in its R&D activities, with students and the industry. Some of the key activities and training programmers carried out during the year are mentioned below.

New Programs

Three M.Tech programs in CSE, IT and VLSI Design commenced at C-DAC, Noida for developing the research aptitude of students in various fields. An MBA (Software Enterprise Management) programme has also been started in 2006-07 with the aim of transforming engineering graduates into quality software project managers.

C-DAC, Hyderabad introduced three courses namely, "Advanced Business Computing Diploma (ABC-D), Certificate Course on Networking and System Security (CNSS) and Diploma in Digital and Analog VLSI Design (D-DAD)".

C-DAC, Thiruvananthapuram has also introduced an M.Tech course in VLSI Design and Embedded Systems in the academic year 2006-2007.

C-DAC, Kolkata will conduct a one year Post Graduate Diploma in Localization under Burdwan University, West Bengal. It will also offer a M. Tech in Courseware Engineering and Post Graduate Diploma in Multimedia in distance multi-modal mode with Jadavpur University. Negotiations are also going on with Burdwan University, Jadavpur University, and West Bengal University of Technology for joint courses on Information Security. C-DAC is also in negotiations with West Bengal Police for a Corporate Training on Cyber Forensics.

Programs for Corporate and Organized Sectors

C-DAC is offering various specialized training programmes for corporate and organized sectors. It is working with the Indian Army since 1999 and has signed an MoU for offering IT training programmes to the Indian Army personnel. Over 8000 personnel are getting trained every year in 16 different courses designed for the Indian Army. Similar training initiatives have been carried out for the Indian Navy.

Under the ITEC/ SCAAP programme, 144 international participants have been successfully trained in seven different training courses.

Advanced Computing Training School (ACTS)

C-DAC's ACTS continued its efforts towards creating high quality manpower for C-DAC in particular and the IT industry in general through the design and delivery of various courses. Its courses are offered through a network of 49 Authorized Training Centres (ATCs) in India, including C-DAC's own centres in Bangalore, Hyderabad, Chennai and Pune.

mPower Series of Modular IT Programmes

The mPower series of programmes of C-DAC ACTS are powerful modular programmes for candidates aspiring for a career in ICT. mPower is targeted towards students from varied background including non engineering/ non IT background who aspire to make a successful career in the IT industry. The course aims to groom the students to enable them to work on current technology scenarios as well as prepare them to keep pace with the challenging face of technology and requirements of the ever growing IT industry. The course curriculum has been designed keeping in view the emerging trends in advanced computing as well as contemporary and futuristic human resource requirements of the ICT industry. The entire course syllabus, courseware, teaching

methodology and course delivery have been derived from the rich research and development background of C-DAC. The depth and methodology of the programme is unique in the industry covering a wide spectrum of requirements of the ICT industry.

PG Diploma in Localization

The Post-graduate Diploma Programme in Localization prepares participants for a career in the localization industry. Localization refers to the adaptation of software, Web sites and the Internet to meet the requirements of international markets. Aspects such as language and culture must be localized so that products and services appear to be specifically developed for a local market. The localization industry addresses these essential needs in one of the fastest growing sectors in high technology. Participants learn general concepts of localization, such as industry expectations, translation tools and processes. They are introduced to multilingual computing, product development, and localization cycles and projects. Common projects bring all participants together to solve problems in teamwork settings. Although the title of this program reflects its focus on software, topics address the localization of Web sites and the Internet as well.

M.Tech and PG-Diploma in Language Technology

Recognizing the demand for skilled manpower in Speech and Language technology fulfilling the need of IT localization industry and understanding Semantic and Syntactic structure of Indian languages, a Post Graduate Degree programme in Language Technology has been initiated in collaboration with Mahatma Gandhi Antrarashtriya Hindi Vishwavidyalaya, Wardha. The first batch of M.Tech. (LT) and PGDLT will pass out soon.

C-DAC GIST - Programme for Advancing Computer Education (PACE)

C-DAC offers various programs ranging from short term Basic Computer awareness programs to Post Graduate level covering all aspects of Multilingual Computing (Certificate, Diploma, Advanced Diploma and Post Graduate Diploma) through a network of 250 Authorized Training Centres (ATCs) spread across 15 states.

PACE has launched a Certificate course in Bharateeya Open Office (a complete Multilingual Office suite) on the eve of the National Independence Day (Aug 15, 2006). GIST PACE has executed major orders from Gujarat Development Department (Phase I) and also from Kerala Health Services Department. Approx. 30000 students including Government employees have been trained during the year 2006-07.

Vernacular Languages (Bangla, Hindi, English) Based Functional-IT Training

- Development of Typing Tutor in Bangla
- Establishing Community Resource Centre at North Bengal State Library, Cooch Behar and functional IT training program from that resource centre.
- Functional IT training program for students at three schools of BANKURA District under SARVA SIKSHA ABHIYAN.
- Content and Software Development for the Information Kiosk installed at State Central Library, Kolkata and Panchayet and Rural Development Cell, Kolkata

Setup of International Centres

- A feasibility study was conducted for setting up of Centre of Excellence in ICT at Tanzania and Seychelles. The feasibility study report has been submitted to the Ministry of External Affairs, Govt of India.
- Bedil India Tajikistan Centre for IT (BITCIT) project at Dushanbe, Tajikistan shall be completed in May 2007. Entire hardware, software and peripherals, course material has been supplied and installed. Eight faculty members from Tajikistan underwent

six months IT training at C-DAC ATC in Delhi. The faculties deployed by C-DAC for the duration of six months (November 2006 to April 2007) for imparting training to the faculties and the students of BITCIT have returned after discharging their duties at Tajikistan

- Jawaharlal Nehru India Uzbekistan Centre for IT (JNIUCIT) project at Tashkent, Uzbekistan is completed in May 2007. Entire hardware, software and peripherals, Course material has been supplied and installed. Eight faculty members from Uzbekistan underwent six months IT training at C-DAC Pune. The faculties deployed by C-DAC for the duration of one year (June 2006 to May 2007) for imparting training to the faculties and the students of JNIUCIT have returned after discharging their duties.

Consultancy

During the reporting period C-DAC has provided consultancy services to various clients, State and Central Government departments covering the areas of education in IT, Entrepreneurship Development, Networking etc. to include Govt. of Punjab, Dept. of Sainik Welfare, Govt. of Uttaranchal, Municipal Corporation, Delhi, Jamia-Milia-Islamia University, National School of Open Education etc. The consultancy service included facilitating industry for providing technology and services, internet facilitation services like website hosting, mail service, server co-location etc.

RESOURCES, FACILITATION SERVICES AND INITIATIVES

Human Resource Development (HRD)

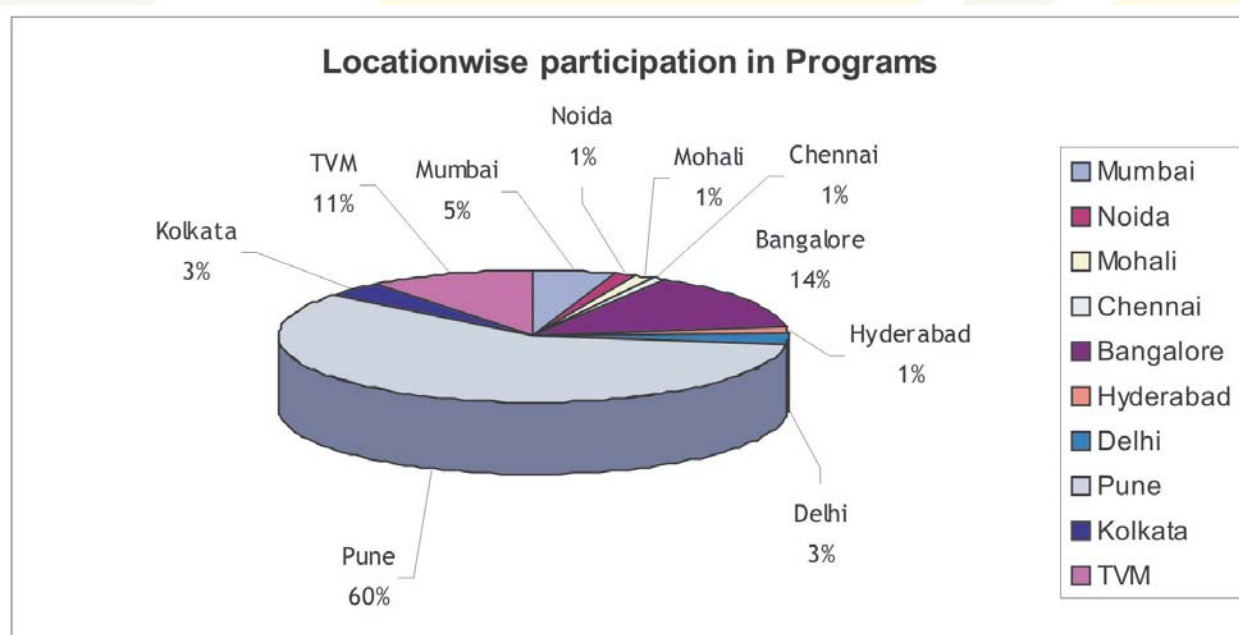
Professional team comprising approximately 2500 employees including regular, contract, and project based employees contributed towards C-DAC's activities.

HRD team at C-DAC strived hard to ensure that the three areas viz. individual, occupational and organizational development occurred. HRD aimed to bring in latest stage in the long tradition of training, education, and developing employees for the purpose of contributing towards the achievement of individual, organizational and societal objectives. HRD intervention through training programs helped the employees of C-DAC to rejuvenate and invigorate the intellectual resources and to act as catalysts in the fulfilment of the objectives.

A training calendar was published for the year 2006-07 with a view to encourage learning in individuals through pragmatic consideration of the underlined theories and their practical applications to reach greater heights in the professional life. The training need survey was conducted earlier and based on it the calendar for the year 2006-07 was created.

C-DAC at corporate level, conducted five Management Development Programmes, eight Programmes in Personal Development and Administration Skills and three in Technical Knowledge. The participation was as given in the graph given below.

Various centres of C-DAC located at Kolkata, Noida, Mohali, Thiruvananthapuram, Mumbai and Pune conducted specialized workshops, skill upgradation programmes and training programmes for the benefit of the staff of respective centres. C-DAC centres apart from the activities mentioned above conducted induction programmes for the new entrants to introduce the new recruits to the various challenging activities of C-DAC.



During the reporting year, C-DAC also faced the problem of attrition. This was mainly because of the boom in the IT industry and demand for skilled manpower. To counter the attrition C-DAC conducted exit interviews of the employees leaving and based on the feedback received from such interviews, swift and effective HRD strategies are put in place to counter the problem of attrition. The efforts includes measures of providing choices of challenging R&D topics, appraisal process with constant feedback, employee satisfaction survey, and refresher training programmes focusing employee development. These steps, to a large extent, helped C-DAC for progressive reduction in attrition.

Legal and IPR

The IPR Watch Project (Providing e-Prompt to concerned Indian Parties the watch reports on National and International IT-Patents C-DAC, Pune) funded by Department of Information Technology was successfully completed during the year. Total 450 patent applications related to Information and Communication Technologies, published in IPO Journals during the calendar year 2005 were analysed as a primary activity of the Project.

Besides, the Knowledge Management Cell in consultation with legal group facilitated filing of patent, copyright, and trademark applications.

The Knowledge Management Cell has processed 33 (Total 152 so far) Copyright Registration Applications and 2 (Total 119 so far) Trademark Registrations, during the year 2006-07.

RTI ACT, 2005

During the year 2006-07, 07 applications were received under RTI Act, 2005. Applications were disposed off as per provisions of RTI Act, 2005.

Library and Information Centre

C-DAC has well equipped and automated libraries attached to Headquarters and Thube Park at Pune, Knowledge Park and Electronics City Bangalore, Noida, Juhu and Kharghar Mumbai, Mohali, Kolkata, Hyderabad and Thiruvananthapuram. These libraries are catering to the needs of members and students of different courses.

C-DAC libraries are actively participating in the MCIT Library Consortium. Under this Consortium, IEEE Digital Library containing complete IEEE and IEE literature has been subscribed for organization wide access. User Awareness and Orientation Programs were held for the benefit of members at various locations.

The Pune Centre library offers current awareness services especially on Grid Computing, Supercomputing, Telemedicine and E-Governance. It also helped local libraries in installing E-Granthalaya, the management software developed by NIC and promoted by MCIT Library Consortium.

C-DAC, Mumbai has its main library located at Juhu, which has an exhaustive collection of print and electronic resources. It also subscribes to ACM Digital library.

The Mumbai library at Kharghar is enhancing its collection in the field of Online and distance learning and Open Source Software besides other computing subjects.

The library at Electronics City Bangalore has a good collection in the field of software engineering besides other computing subjects. Libraries at Knowledge Park, Electronics City Bangalore and Thube Park, Pune adopted the E-Granthalaya library management software.

The library at Knowledge Park, Bangalore launched a Digital Repository wherein the open source digital repository software Dspace is being used. Future plans are to make it into the C-DAC Knowledge Management Portal.

C-DAC, Thiruvananthapuram has a well-equipped library (Technical Information Centre). The library is automated using library management software WEBLIBMAN developed by the Thiruvananthapuram centre.

C-DAC, Mohali Library has been rendering reference, referral and reprographic services.

Awards

C-DAC, Thiruvananthapuram received an Industry Appreciation Award and a citation from Naval Science and Technological Laboratory (NSTL), Visakhapatnam.

Conferences/ Events Organized

1. One-day workshop titled "FOSS @ C-DAC" was organized by C-DAC, Chennai at VGP Resorts, Chennai on December 1, 2006.
2. "BOSS Linux User Awareness" training was organized by C-DAC, Chennai for officials of the DIT during February 2007.
3. One-day workshop on "Towards Securing End Systems in the Networked World –Challenges and Possible Solutions" was organized by C-DAC, Hyderabad during June 27, 2006.



4. Two-day India – ASEAN Seminar on "E-Learning and E-Learning Technologies" was organized by C-DAC, Hyderabad during November 6-7, 2006.
5. Five-day training programme on "e-Suraksha (A practical approach in Network Security)" was organized by C-DAC, Hyderabad during May 20-24, 2006, Oct 30-Nov 3, 2006 and March 5-9, 2007.
6. One-day national workshop on "Supply Chain Management Solutions for Industries to Enhance Profitability" was organized by C-DAC, Hyderabad on September 9, 2006.
7. One-day workshop on "e-Learning for NGOs" as part of India Development Gateway (InDG) project was organized by C-DAC, Hyderabad on December 12, 2006.

8. Two-day workshop on “Linux Device Drivers (WorLD)” was organized by C-DAC, Hyderabad during March 1-2, 2007.
9. Two-day workshop on “e-Learning” was organized by C-DAC, Hyderabad during March 9-10, 2007.
10. One-day workshop on “Content Development for Universalization of Education and Child Rights” as part of India Development Gateway (InDG) project was organized by C-DAC, Hyderabad on March 9, 2007.
11. INDO-ASEAN Seminar on “Shruti Drishti – An Integrated Text-to-Speech and Text-to-Braille System for Visually Impaired” was organized by C-DAC, Pune during January 18-19, 2007.
12. LRIL 2007, National Seminar on “Creation of Lexical Resources for Indian Languages”
13. Shubham Bhavatu 2007, National Seminar on Oral tradition and written text of Indian Languages with special reference to Vedic Sanskrit was organized by C-DAC, Noida during March 10-11, 2007.
14. 2nd Workshop on Free and Open Source Softwares (FOSS): “Standardisation and Localisation of Indian Languages” was organized by C-DAC, Noida on July 26, 2006.
15. Three two-day workshops were organized during February 27-28, 2006 at Pune, February 02 – 03, 2006 at Mumbai and January 22-23, 2007 at Delhi, under the INCITE project with an objective to promote the participation of the Indian IT constituency into the ICT community Framework Programme of European Commission.
16. International Workshop on “Research Issues of Digital Library” was organized by C-DAC, Kolkata jointly with ISI, Kolkata and IIT, Kharagpur during December 12-15, 2006.

Participation in Conferences/ Workshops

1. April 2, 2006: Symposium on Modeling and Shallow Parsing of Indian Languages at IIT-Mumbai
2. April 6, 2006: Seminar on High Performance Analog Technology at Hotel Leela, Bangalore
3. April 25, 2006: International Workshop and Training on IEC61850 at CPRI, Bangalore
4. May 26, 2006: Essential Technologies for Automotive Test at Hotel Muthoot Plaza
5. June 6, 2006: Reliability and Practical Cooling in Electronics at Sameer Centre, Chennai
6. July 12, 2006: National Workshop on IPR in Semi Conductor Chips and Product at School of Computing, Thanjavur
7. August 11, 2006: Symposium on Cyber Forensics and Computer Crimes at Punjab University, Patiala
8. August 12, 2006: National Seminar on Technological Innovations at Kanakakkunnu Palace
9. August 23, 2006: E-Gov India 2006 at New Delhi
10. August 31, 2006: TIC600 and Da Vinci DSP Programming Workshop at Texas Instruments, Bangalore
11. September 5-7, 2006: Workshop on RFID
12. September 8, 2006: Connect 2006- Creating a Knowledge driven ECO System at Chennai
13. September 12-27, 2006: Workshop on “Information Security”
14. September 15, 2006: Space Technology Utilization for Development of Kerala at Mascot Hotel, Thiruvananthapuram
15. September 22, 2006: National Conference on Mobile Computing at Technopark, Thiruvananthapuram
16. October 12-15, 2006: “National Symposium on Instrumentation” at Delhi arranged by Institute of Technology and Management, Gwalior
17. November 6-7, 2006: Workshop on “e-learning Technologies”

18. November 21, 2006: Srishti 2006 at Technopark, Thiruvananthapuram
19. November 24, 2006: MEDITEL 2006 at Amrita Institute
20. November 28, 2006: TI Developer Conference at NIMHANS, Bangalore
21. December 1, 2006: Wireless Networking at Technopark, Thiruvananthapuram
22. December 2-3, 2007: International Conference on The Role of the State in a Liberalized Economy organized by ILS Law College, Pune in collaboration with the European Public Law Centre, Athens
23. December 12, 2006: Power Electronics Drives and Energy System at IIT-Delhi
24. December 15, 2006: Data Centre and Server Room Cooling at Mascot Hotel, Thiruvananthapuram
25. January 2007: Indian Science Congress at Chidambaram, Tamil Nadu
26. January 4-6, 2007: FOSS.IN Science exhibition organized by SPACE (Society for Alternative Computing and Employment), Kerala held at Kochi
27. January 8, 2007: Symposium on the Research of Speech and Music at Mysore
28. January 8, 2007: International Conference on VLSI Design at Bangalore
29. January 10 -11, 2007: ELITEX 2007 exhibition held at the India Habitat Centre in Delhi
30. January 12, 2007: Cost and Management Conference 2007 at Kochi
31. January 19, 2007: RFID Expo Live India 2007 at Bangalore
32. January 31- February 2, 2007: Linux Asia 2007 conference held at the India Habitat Centre in New Delhi
33. February 1, 2007: BES Expo 2007 at Pragati Maidan, New Delhi
34. February 4-9, 2007: Telemedicine Conference held at Malaysia
35. February 5, 2007: Vision Summit 2007 at Hyderabad
36. February 22, 2007: ICSCN2007 at MIT, Chennai
37. February 26, 2007: Automation and Information Technology at Ranchi

Papers Published

1. Mohit Dalvi, Gufran Beig, Uday Patil, Akshara Kaginalkar, C. Sharma and A.P. Mitra, - "A GIS based Methodology for Gridding of Large-scale Emission Inventories: Application to Carbon-monoxide Emissions over Indian Region", *Atmospheric Environment*, 40 (16) May 2006, p. 2995-3007
2. Sajeevan G. - "Customise and Empower", *Geospatial Today*, April 2006, p.40 to 43
3. Jaishanker R. and Johnson C.P. - "Geomatics and Public Health" *Indian Journal of Public Health*, Vol. 50, No. 1, 2006, pp.24-27.
4. Johnson C.P. - "Now, Fire Response Planning Gets Easy", *Geospatial Today*, Vol. 4, Issue 5, 2006, pp. 28-32.
5. Sajeevan G. - "Extending GIS to the Common Man through Image-based Vector GIS", *Current Science*, Vol. 92, No.6, 2007
6. Sajeevan G., Ailawar S. and Chhillar S - "Integrating GIS and MIS", *GIM International*, Vol. 21, Issue 2, 2007
7. Sajeevan G., Raja V.K.M., Mhatre J. and Banerjee B. - "Development through GRIMMS Web", *Geospatial Today*, Vol. 4, Issue 11, 2006, pp 30-32.
8. Singh Y.K. and Dutta U. - "Dynamic Segmentation, a Tool for Infrastructure Development - Case Study", *Geospatial Today*, Vol 5, Issue 1, 2006, pp 28-30.
9. Singh Y.K. and Kaushal A. - "Extraction of Geomorphological Features using Microwave Remote Sensing Data - A Case Study", *Journal of Indian Society of Remote Sensing*, Vol 34, No.3, 2006, pp 299-307.10. Vinoth Kumar J.A., Pathan S.K. and Bhandari R.J. - "Spatio-temporal analysis for Monitoring Urban Growth - A Case Study of Indore City", *Journal of the Indian Society of Remote Sensing*, Vol. 35, No. 1, 2007

10. Smitha Ghosh, Archika C. Barve, Anupa A. Kumbhar, Avinash S. Kumbhar, Vedavati G.Puranik, Prasanna A.Datar, Uddhaves B. Sonavane, Rajendra R.Joshi – “Synthesis, characterization, X-ray structure and DNA Photocleavage by Cis-dichloro Bis(Diimine) Co(III) Complexes”, *Journal of Inorganic Biochemistry*, 100(3), 331-343.
11. Rangrez A Y, Dayananda KM, Atanur Santosh, Joshi Rajendra, Patole MS, et al. – “Detection of Conjugation Related Type Four Secretion Machinery”, *Aeromonas Culicicola*, PLoS ONE 1(1): e115, 2006
12. S. S. Kadam, S. K. Das, A. S. Warke - “Estimation of Contaminant Transport in a Layered Aquifer using Artificial Neural Networks and Finite Difference Method”, *International Journal of Applied Mathematics and Engineering Sciences (IJAMES)*, Vol. 1, No. 1, Jan-Jun 2007, pp. 149-164
13. Vikas Kumar, D.Gangacharyulu, R.G Tathgir - “Thermal Performance Evaluation of Heat Pipe Heat Exchangers under Natural Convection”, *International Journal of Heat Exchangers*, Vol.VII, Issue 1, 2006
14. Amit P Kesarkar, Mohit Dalvi, Akshara Kaginalkar and Ajay Ojha – “Coupling of the Weather Research and Forecasting Model with AERMOD for Pollutant Dispersion Modeling. A Case Study for PM10 Dispersion over Pune, India”, *Atmospheric Environment*, 41 (6), pp 1976-1988.
15. J.Venkata Ratnam, D.R.Sikka, Akshara Kaginalkar, Amit Kesarkar, N. Jyothi, Sudipta Banerjee – “Experimental Seasonal Forecast of Monsoon 2005 using Global T170L42 on PARAM Padma”, (accepted for publication in *Pure and Applied Geophysics*).
16. Prabu D, Andrew Aaron James, Vanamala V, Vineeth Simon, Sanjeeb Kumar Deka, Sridharan R, Prahlada Rao BB, Mohanram N. – “An Efficient Run Time Interface for Heterogeneous Architecture of Large Scale Cluster Computing”, *In International Enformatika Trans on Engineering, Computing and Technology*, Vol. 17, pp 305 –309 , Dec 2006, Cairo, Egypt, ENFORMATIKA V17, ISSN 1305-5313. <http://www.enformatika.org/data/v17/v17-59.pdf>
17. Prabu D, Vanamala V, Sanjeeb Kumar Deka, Sridharan R, Prahlada Rao BB, Mohanram N. – “A High Performance MPI for Parallel and Distributed Computing (Gigabit Ethernet Approach)”, *International Enformatika Trans. on Engineering, Computing and Technology*, Vol. 17, pp 310 –313, Dec 2006, Cairo, Egypt. ENFORMATIKA V17, ISSN 1305-5313, <http://www.enformatika.org/data/v17/v17-60.pdf>.
18. Prabu D, Anshu Garg, Vanamala V, Sridharan R, Prahlada Rao BB, Mohanram N. – “64-bit Message Passing Interface for Large Scale Cluster Computing”, *WSEAS TRANSACTIONS ON COMPUTER RESEARCH* ISSN: 1991-8755, Feb 2007
19. Roohi Sabrin, DeviPrasad, Prabu D, Pallavi R S, Revathi P., “Memory Leak Detection in Distributed System”, *International Enformatika Transactions on Engineering, Computing and Technology*, ENFORMATIKA V16, ISSN 1305-5313, Vol-16, pp 78-83, Nov 2006, Venice, Italy, <http://www.enformatika.org/data/v16/v16-15.pdf>
20. Bindhumadhava BS : eGov Framework: A Development Approach: An Application Prototype Implementation' for egov India 2006 conference during August 2006. The paper published in *eGov Magazine*, October 2006 issue.
21. 24. SP Sood, JS Bhatia – “Telemedicine and the Elusive Network-Effect”, *ICT 4 Development*, Vol.4(4), pp 25-27, April 2006.
22. Shashwat Chaturvedi, Sanjay Sood et al. – “Doc's Prescription for Telemedicine”, CIOL available at <http://www.ciol.com/content/special/anniversaryspecial/default-2.asp?aid=17> & <http://www.moneycontrol.com/india/news/tech/docsprescriptionfortelemedicinetelemedicine/docsprescriptionfortelemedicine/market/stocks/article/238775> (August 2006)
23. N Dani, SP Sood, VWA Mbarika, N Prakash, Rajeev Agrawal - GIS and Telemedicine Tools for Public Health, *eHealth*, Vol.1 No. 1, November 2006, pp 11-15.
24. SP Sood, N Prakash, VWA Mbarika, Identifying Technical Actants in Telemedicine Adoption, *Communications of Computer Society of India*, Vol. 40, February 2007, pp 32-35
25. Urjaswala Vora and N. L. Sarda - “Architectural Design Issues for Evolving Systems” *WSEAS Transactions on Systems*, Issue 4, Volume 5, April 2006, ISSN 1109-2777, <<http://www.wseas.org>>.
26. Alka Irani and Zia Saquib - “Linguistic Resource for User Friendly Computing”, *Vishwabhaarat@TDIL* (to appear).



C-DAC, Pune celebrates its 20th Foundation Day on March 19, 2007



C-DAC showcased the best of the technologies and tools from the C-DAC R&D stable at TechShow – Technology Showcase and Seminar during March 17 - 18, 2007

