



techzine

C-DAC R&D DIGEST

APRIL 2023 – JUNE 2023

VOLUME 1, ISSUE 1

IDEAS TO ACTION | PROGRESS PULSE: A PERFORMANCE DASHBOARD | TECH ROLL-OUTS | SIGNIFICANT CONTRIBUTIONS

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Message from Director General

A technical digest serves as a valuable communication tool for knowledge dissemination & insights and it is an excellent way to connect with the internal as well as external stakeholders. It provides a platform to share the trends as well as best practices in the industry and connects researchers, professionals, enthusiasts; encouraging networking and collaboration. The digest provides a direct channel to communicate new R&D initiatives, product updates, new features, and improvements to users and customers.

C-DAC teams across 12 centers are working diligently on developing state-of-the solutions in various domains contributing to national level initiatives. Techzine is an attempt to motivate, provide effective opportunities and handhold our fellow researchers at C-DAC, to develop strong research competencies and a broader appreciation of the value and need for distributed research to solve some of the emerging technological challenges in turn resulting into adding value for the whole ecosystem.

I wish Techzine R&D Digest enables creation of a knowledge sharing environment across researchers and professionals to share latest research & development activities and events in Information Technology and Electronics area, and also facilitate in initiating interdisciplinary collaborations across researchers.

Going ahead, this Techzine digest will be issued on a quarterly basis. I applaud this initiative by Corporate R&D and efforts for coming up with a R&D Digest of C-DAC for the first time.

I request all of you to utilize this platform to share more of your research activities to make it an effective medium for all of us to communicate, share, discuss and ignite minds with the latest developments happening in our C-DAC community.

Shri. Magesh Ethirajan



Message from **Editorial Board**

The major objective of this digest is to enhance Research Collaborations within C-DAC and proliferate C-DAC's R&D achievements to the stakeholders. Techzine has 7 key sections. While the sections 'Ideas to action' and 'Progress Pulse' give much more insight into the latest R&D activities of C-DAC, 'Tech Rollout', 'Collaboration' and 'Events' sections detail more about our Products/Solutions launched and C-DAC's partnerships with other organizations. It also has sections on 'Backend Squad' and 'Inspiring Insights' wherein prominent researchers from C-DAC and other places share their knowledge and expertise with us.

Editorial Board

- Mr. Pramod P.J., Head – Corporate R&D
- Mr. Manoj Gopinath, Head M&C, Associate Director, C-DAC Pune
- Ms. Neeti Vohra, Associate Director, Corporate R&D
- Mr. Shripad Kalambkar, Joint Director, Corporate R&D
- Mr. Anant Kelkar, Manager, Corporate R&D
- Mr. Sanjay Chakane, Admin Officer, Corporate R&D

IDEAS TO ACTION



NEW MEITY PROJECTS IDEAS TO ACTION

1



Name of Project:
Design and Development of System-on-Chip for Single-Lead Wearable Electrocardiogram (ECG) for Medical Devices

CI: Dr. Balwinder Singh

Co-CI: Dr. Mandeep Singh

Collaborators: C-DAC Mohali (Nodal), National Institute of Technical Teachers Training & Research (NITTTR) - Chandigarh, University Institute of Engineering & Technology (UIET) - Chandigarh, Sant Longowal Institute of Engineering and Technology (SLIET) - Longowal, Punjab

Brief Description: This project is focussing on the design and development of system-on-chip for single-lead wearable electrocardiogram (ECG) for medical devices in the collaboration with three other participating institutes. The project comes under the Chip to Startup programme of MeitY.

NEW MEITY PROJECTS IDEAS TO ACTION

2



Name of Project:
Study and analysis of issues related to Malicious Content in social media, cyber threat, data safety and Mitigation through Legal provisions and measures

CI:Dr. Mary Jacintha M

Brief Description: The project is to study and analyze the issues related to malicious content in social media for data authenticity, security and privacy associated cyber threat, data safety and mitigation through Legal provisions and measures. Techno-Legal support would be provided to MeitY by analyzing various tools used for phishing attacks such as Bots, Phishing Kits, Technical Deceit, Session Hijacking, Abuse of DNS, Specialized Malware etc; analyzing the issues related to data authenticity, privacy & security; analyzing ways and means to prevent fake news on social media and proposing the counter measures such as strong authentication & authorization, Virus, spam & spyware prevention, etc. Also, proposing a draft regulatory framework with focus on blockchain infrastructure to address the issues pertaining to data storage, privacy, taxes, acceptance of cryptos as legal tender etc

NEW MEITY PROJECTS IDEAS TO ACTION

10

3

Name of Project: HPC-based Quantum Accelerators for enabling Quantum Computing on Supercomputers

CI: Col A.K Nath (Retd.) Executive Director and Director Corporate Strategy
Co-CI:

- Mr. Amit Saxena, C-DAC Pune
- Mr. Amit Srivastava, C-DAC Pune
- Mr. Samrit Kumar Maity, C-DAC Pune
- Mr. Abhishek Tiwari, C-DAC Noida
- Dr. Kunal Abhishek, C-DAC Patna
- Mr. Soumya Bhowmik, C-DAC Patna
- Mr. Asvija B, C-DAC Bengaluru
- Mr. Henry Sukumar, C-DAC Bengaluru
- Mr. Vivek Nainwal, C-DAC Hyderabad

Collaborators: C-DAC Pune, Bengaluru, Noida, Hyderabad and Patna

Brief Description: The objective of this project is to build a Quantum Accelerator based on HPC nodes to achieve computational tasks that are beyond capabilities of available Quantum Simulators.

4



Name of Project: Development of unmanned robotic ground vehicle for safe spray application for agro chemicals

CI: Dr. Mandeep Singh

Collaborators: Central Potato Research Institute-ICAR, Jalandhar Punjab

Brief Description: Modern agriculture globally is highly reliant on the large-scale application of agro-chemicals for the management of insect pests, diseases and nutrients. Currently, various types of spraying systems are being used for the application of agro-chemicals. Most of the tractor/power operated sprayers cannot enter in to the crop fields due to their weight; difficulty in manoeuvrability and possible crop damage. The farmers generally apply agro-chemicals using knapsack or gun type sprayers wherein the operator is in close proximity of the sprayed chemicals. This is extremely harmful to the operators as they inhale lot of air suspended particles of chemicals which is a serious health hazard. Besides, a precise application as per the canopy cover is not possible with these sprayers, which leads to wastage of chemicals and environmental pollution. Therefore, this study is planned to develop a remotely controlled unmanned ground vehicle (UGV) for precise and targeted application of agro-chemicals. The UGV includes energy efficient power supply system, controlled agro-chemical application systems and remotely operated GPS guided navigation and control systems mounted on a four-wheel drive high clearance robotic vehicle.

IDEAS TO ACTION (External Funding)

PROGRESS PULSE:

A PERFORMANCE
DASHBOARD



IPR PORTFOLIO

Corporate IPR Cell has been established at C-DAC to create awareness and increase C-DAC's IPR footprint. World IPR day was celebrated by C-DAC on 26th April 2023 in a function with release of C-DAC IPR registry, list of published papers during the last decade and Invited talks by eminent personalities. Chief Guest Adv. Uma Devi.M, Advocate on record, Supreme Court of India and IPR & Patent Attorney delivered a talk on this year's theme "Women and IP: Accelerating innovation and creativity".

The Keynote speech on "Relevance of IPR in Research & Technology Transfer" was delivered by Shri R S Praveen Raj, Principal Scientist, CSIR. Function was presided over by Shri. Magesh E, Director General, C-DAC.



	IPR portfolio of C-DAC (Year 2013 to 2023 (upto March)			Quarterly IPR portfolio of C-DAC (April to June 2023)		
	Patents	Copyrights	Trademarks	Patents	Copyrights	Trademarks
Applied /Filed	62	15	-	8	3	-
Granted/Registered	74	138	21	2	0	-
Total	136	153	21	10	3	-

MAJOR PROJECT PERFORMANCE/ STATISTICS

NATIONAL SUPER COMPUTING MISSION

The National Supercomputing Mission (NSM) was initiated in April 2015 with a budget outlay of Rs 4500 Cr for seven years to be jointly implemented by MeitY and DST. The budget share of MeitY and DST are Rs. 1760 Cr and Rs. 2740 Cr respectively. C-DAC and IISc are the executing agencies. Key deliverables of the mission are;

- HPC infrastructure creation across the nation
- R&D for exa-scale readiness and self-reliance in HPC
- Development of applications for national need in at least five domains
- Development of Human Resources (~20,000) for managing HPC

Main thrust in the National Supercomputing Mission (NSM) is to provide the Supercomputing Infrastructure of varying compute capacities to the Academia, Researchers, MSMEs and Start-ups for meeting their compute needs and to create the capability of Design and Manufacturing of the Supercomputers indigenously in India, under the Make-in-India initiative of the Government of India. C-DAC has been entrusted with the responsibility to design, deploy and commission the Supercomputing systems under the build approach of Mission.

Till now 15 NSM systems are functional across the nation and more than 122 organisations (coming under academia and R&D) are using the system, No of Successful Jobs completed in NSM systems (nationwide) till date is Approximately Rs. 83 Lakhs.

More than 19,500 Manpower trained in the field of HPC till date.

Under the Mission, as on date, 15 PARAM supercomputers have been built and installed across the nation and 122 organisations (coming under academia and R&D) are using these system. These systems are manufactured in India with indigenous software stack having compute capacity of 24 Peta Flops.

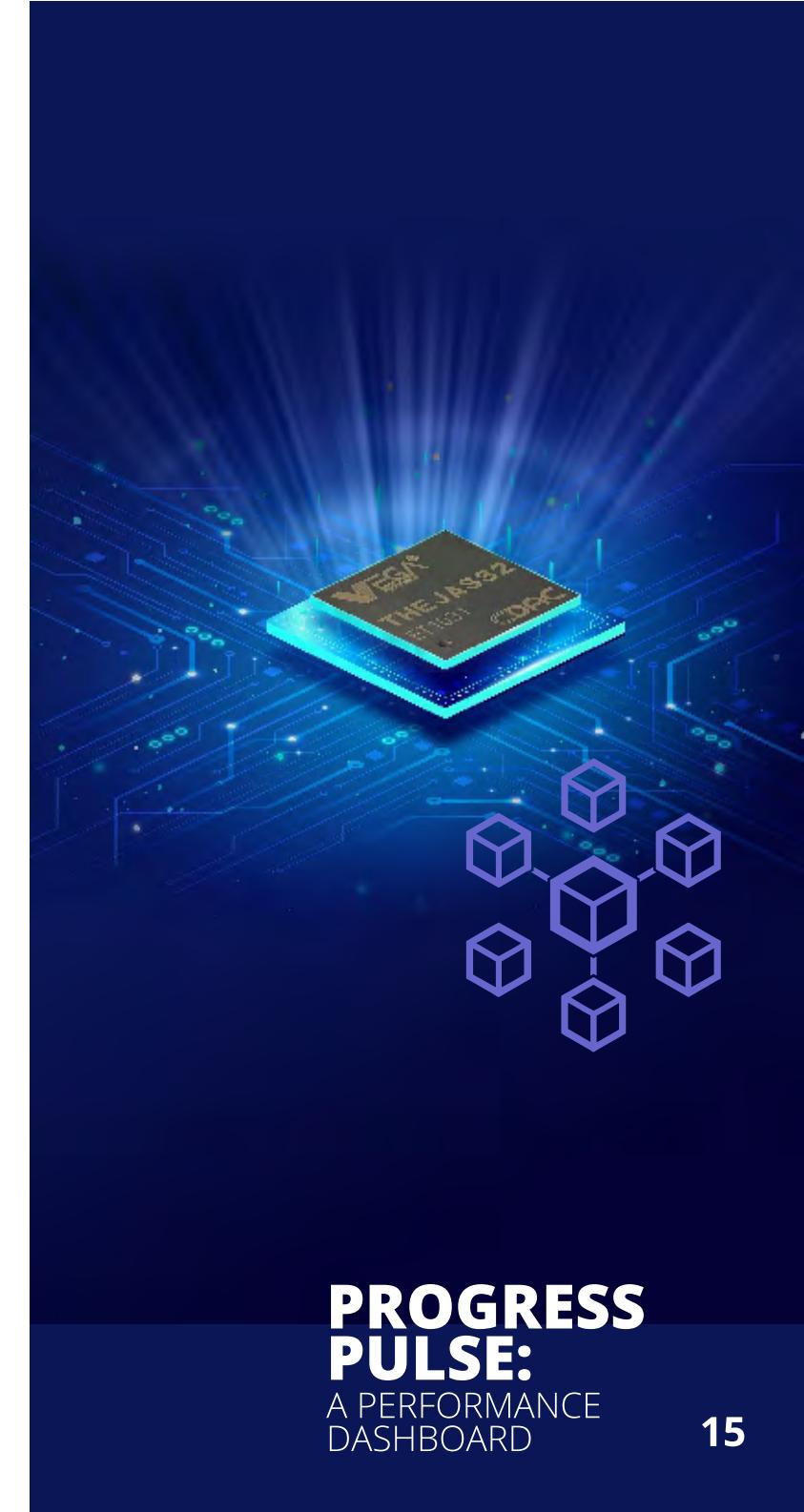


MAJOR PROJECT PERFORMANCE/ STATISTICS

Digital India RISC-V (DIR-V) Program:

C-DAC has successfully completed the design and development of the VEGA series of microprocessors (www.vegaprocessors.in) including India's first indigenous 64-bit multi-core RISC-V based Superscalar Out-of-order Processor. The VEGA series comprise of 32/64-bit Single/Dual/Quad Core superscalar Out-of-Order high performance processor cores based on RISC-V Instruction Set Architecture with Multilevel Caches, Memory Management Unit and Coherent Interconnect. Five processors are currently available in the VEGA series, viz. ET1031 (32-bit Single Core 3-stage In-order), AS1061 (64-bit Single Core 6-stage In-order), AS1161 (64-bit Single Core 16-stage Out-of-Order Superscalar), AS2161 (64-bit Dual Core 16-stage Out-of-Order Superscalar), AS4161 (64-bit Quad Core 16-stage Out-of-Order Superscalar). The Microprocessors are available as soft IPs amenable/ customizable for performance/power targeted for various strategic/industrial/commercial applications.

National Blockchain Framework (NBF) is an initiative to make India ready for large scale adoption of Blockchain technology and enable trust for applications in the domain of e-Governance. It focuses on enabling Blockchain-as-a-Service and addresses the research challenges across various layers of the Blockchain stack. The stack consists of several components such as a dashboard for automated network setup, generic smart contract layer, authentication and authorization functions, certifying authority and a set of Open APIs for accessing the Blockchain application. It includes security vulnerability assessment test suites for auditing smart contracts and Interoperability support between Hyperledger Fabric & Sawtooth Blockchain platforms. As part of the project 4 patents and 26 Research Papers are published. Infrastructure is setup at two Data Centres and application development with various Government departments is ongoing.



MAJOR PROJECT PERFORMANCE/ STATISTICS

eSanjeevani:

eSanjeevani is the National Telemedicine Service of Ministry of Health & Family Welfare (MoHFW), Government of India. Owing to its widespread and speedy adoption eSanjeevani has evolved into the world's largest documented telemedicine implementation in the primary healthcare.

National Telemedicine Service is testimony to the fact that digital health has come of age in India. eSanjeevani has revolutionised primary healthcare in India by bringing health services to the masses in rural areas and isolated communities.

eSanjeevani Report: National				
	Nov 2019 to June 2023		In June 2023	
	Total Tele-Consultations	Providers	Total Tele-Consultations	Providers
eSanjeevani	13,27,13,614	75,181	97,16,814	2705
eSanjeevaniAB-HWC	12,23,29,931	43,379	97,00,632	2087
eSanjeevaniOPD	1,03,83,683	31,802	16,182	618



MAJOR PROJECT PERFORMANCE/ STATISTICS

e-Hastakshar / e-Sign:

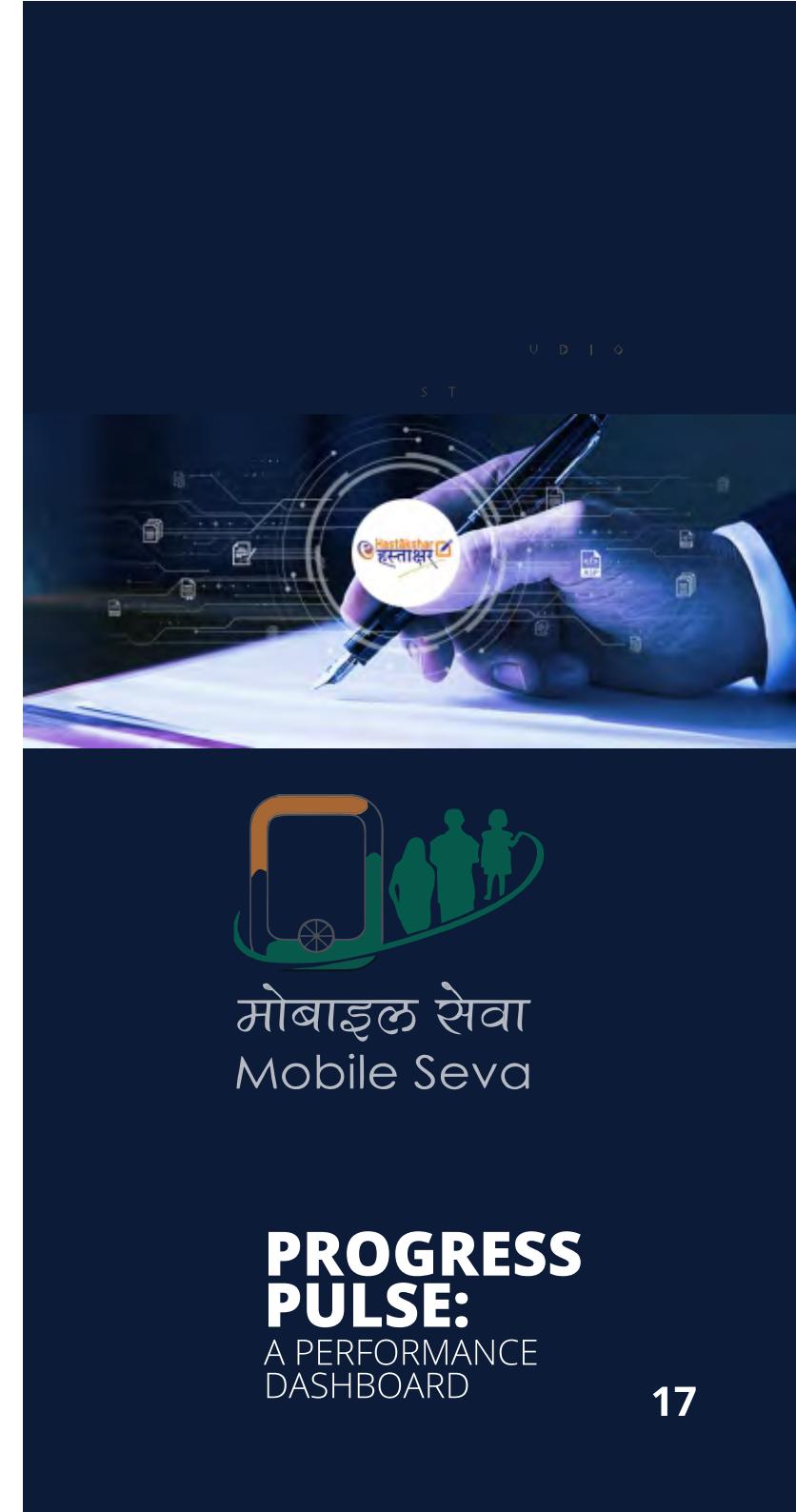
As part of the Government's Digital India Initiative, C-DAC has developed e-Hastakshar – C-DAC's eSign service that facilitates instant signing of documents online based on Aadhaar authentication. During the year, C-DAC carried out integration with government applications and more than 10.67 Cr e-Signs have been offered by C-DAC till 30th June 2023.

eSigns offered by C-DAC	
July 2016 to March 2023	Apr-June 2023
85,160,837	10,451,307

Mobile Seva (Mobile Service Delivery Gateway)/ Mobile Seva Appstore:

Mobile Seva platform is an innovative initiative aimed at mainstreaming mobile governance in the country. It provides an integrated whole-of-government platform for all Government departments and agencies in the country for delivery of public services to citizens and businesses over mobile devices using SMS, USSD, IVRS, CBS, LBS, apps and AppStore. It is a centrally hosted cloud-based mobile enablement platform, which allows the departments to expeditiously start offering their services through mobile devices anywhere in India, without having to invest heavily in creating their separate mobile platforms. Over 4639 accounts of government departments and agencies are integrated with Mobile Seva platform. Over 5,330 crore transactions and 9 cr + apps download have taken place.

Mobile Seva platform		
Particulars	April 2012 to March 2023	April to June 2023
Accounts of Dept/Agencies	4595	55
No of Push SMS Transaction	5385 Crores	2.8 Lakhs
No of apps	1181	68



MAJOR PROJECT PERFORMANCE/ STATISTICS

Information Security Education and Awareness (ISEA) Project Phase II:

Under ISEA Project Phase II, three Cyber Jaagrootka (Awareness) Diwas programs were conducted for employees of MeitY and its organizations by covering 1178 participants on Cyber Awareness topics, "Identification of Social Media Fraud and Security Measures", "Aadhaar and Digital Financial Security" and "Awareness on Dark web frauds and security measures". Under the awareness activities, 22 awareness workshops were organized by covering 6542 participants. Quizzes on Digital Financial Security and Social Engineering Attacks & Security Measures were organized covering 62831 participants

Information Security Education and Awareness (ISEA) Project Phase –II : National		
ISEA Activities	April 2015 to June 2023 Total number of candidates	April 2023 to June 2023 Total number of candidates
Academic Activities	3,75,835 candidates (including 2.85 lakhs candidates from five Technical Universities and affiliated colleges)	1,245 candidates trained/are undergoing training
Government Officials Training	27,904 Government officials	775 Government officials
Awareness Activities	5.75 crore beneficiaries have been impacted through various activities under indirect mode 3.18 candidates (1519 workshops) 1.24 Teachers Trained	6,542 Participants (22 awareness workshops) 62,831 participants through Digital Financial Security and Social Engineering attacks and Security measure quizzes 2 Online Courses in Cyber Security on Karmayogi Bharat Platform



**PROGRESS
PULSE:**
A PERFORMANCE
DASHBOARD

MAJOR PROJECT PERFORMANCE/ STATISTICS

Future Skill PRIME

MeitY and NASSCOM have jointly conceived a programme titled "FutureSkills PRIME (Programme for Re-skilling/Up-skilling of IT Manpower for Employability)". The Programme is envisaged to provide re-skilling/ up-skilling opportunities for B2C beneficiaries in 10 emerging technologies viz. Internet of Things, Big Data Analytics, Artificial Intelligence, Robotic Process Automation, Additive Manufacturing/ 3D Printing, Cloud Computing, Social & Mobile, Cyber Security, Augmented Reality/Virtual Reality, and Blockchain. Under the programme, so far, 14.24 lakh+ candidates have signed-up and around 5.52 lakh+ candidates have got enrolled in various courses, out of which, 2.46 lakh+ candidates have completed the courses. Also, the Resource Centres (C-DAC & NIELIT Lead/Co-Lead Centres), have trained 3810 candidates under bridge courses, 10028 Government Officials (GoT) & 1843 Trainers (ToT).

FutureSkills PRIME Report: National				
	Dec 2019 to March 2023		April 2023 to June 2023	
Sign Ups	1329079		95024	
	Enrolled	Certified	Enrolled	Certified
Government Officials Training	5232	3985	504	426
Training of Trainer	826	752	441	341
Bridge Course	5435*		6306*	

*Dec 2019 to May 2022: Development of 10 e-Lab in 10 emerging technologies; Development of course content in 10 emerging technologies and NOS for industry acceptance; Development of Question Bank for NASSCOM Assessment which was live from May 2022. FutureSkills PRIME Platform launched on Oct'21 by Minister of State; Training for Bridge Course started from 2022 and only enrolled learners data is depicted as the certification will take 4 to 6 months duration



**PROGRESS
PULSE:**
A PERFORMANCE
DASHBOARD



ED TO LANDING PAD



TECH ROLLOUTS

SYSTEM/ PRODUCT/ SERVICES LAUNCH/ RELEASE

TECH ROLLOUTS

SYSTEM/ PRODUCT/ SERVICES LAUNCH/ RELEASE



Launch of Rajmarg Yatra Mobile App developed by C-DAC

Thiruvananthapuram by Hon'ble Union Minister for Road Transport and Highways Shri Nitin Gadkari.



Launch of PRIME

Shri Alkesh Kumar Sharma, Hon'ble Secretary, Ministry of Electronics and Information Technology (MeitY), launched the Project Review & Information Management Electronics (PRIME) System developed by C-DAC, Noida.

Launch of C-HUK Project Outreach in North Eastern Region

Centre for HPC Upskilling and Knowledge Sharing (C-HUK) was launched at NEDFi (North Eastern Development Finance Corporation Ltd.) Guwahati

Launch of NANDI

Hon'ble Union Minister of Fisheries, Animal Husbandry & Dairying, Shri. Parshottam Rupala, launched the **NOC Approvals for New Drugs and Inoculation System** (NANDI) portal developed by the C-DAC, Noida at Krishi Bhawan in New Delhi.

TECH ROLLOUTS

INTERNATIONAL OUTREACH



Hon'ble External Affairs Minister of India, Dr. S. Jaishankar inaugurated **India – Namibia Centre of Excellence in IT (IN-CEIT)** setup by C-DAC at Namibia University of Science & Technology (NUST) in Windhoek



Launch of The Indo-Argentina Center of Excellence in Information Technology (IA CEIT)

To promote knowledge exchange, educational opportunities, and technological projects between India and national universities in Argentina.

SIGNIFICANT COLLABORATIONS



MoU signed with IIT Bombay for Setting up of 3 PF HPC Facility under National Supercomputing Mission

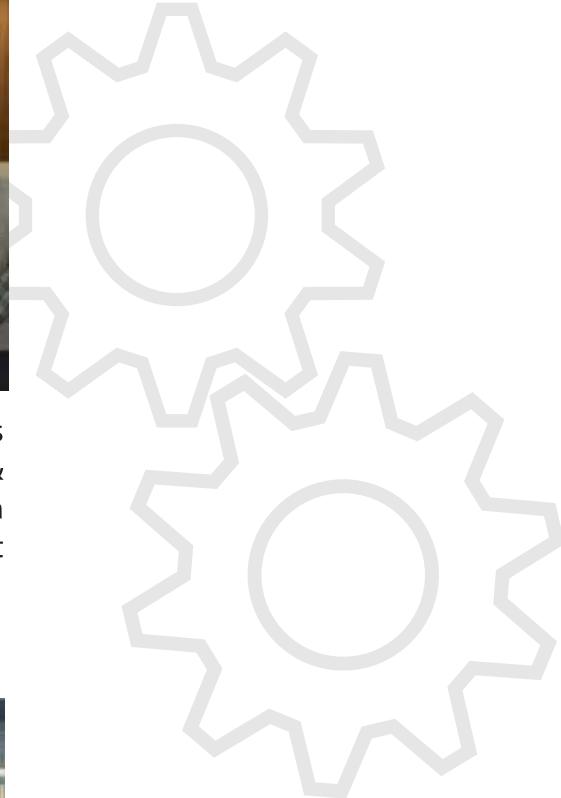


A Memorandum of Understanding (MoU) has been inked between C-DAC and IIT Bombay for setting up a state-of-the art 3 PF HPC facility at IIT, Bombay under National Supercomputing Mission.

MoU with IIT, Patna to establish a Supercomputing System under National Supercomputing Mission



A Memorandum of Understanding (MoU) has been inked between C-DAC and IIT Patna & for setting up a Supercomputer at IIT Patna under National Supercomputing Mission at IIT, Patna.



MoU signed with Govt of Telangana



A MoU was signed between Shri. Jayesh Ranjan, IAS, Principal Secretary, IT and I&C, Govt of Telangana and Shri. E Magesh, Director General, C-DAC at Hyderabad to provide access to the startups working in AI technologies to C-DAC AI computational resources.

MoU signed with UIDAI



MoU signed for undertaking a PoC to implement "Consent Management System on National Blockchain Framework (NBF)" between C-DAC and UIDAI at HQ UIDAI. As part of PoC implementation, it is proposed to integrate the authentication functionality of Aadhaar Enabled Biometric Attendance System (AEBAS), with the

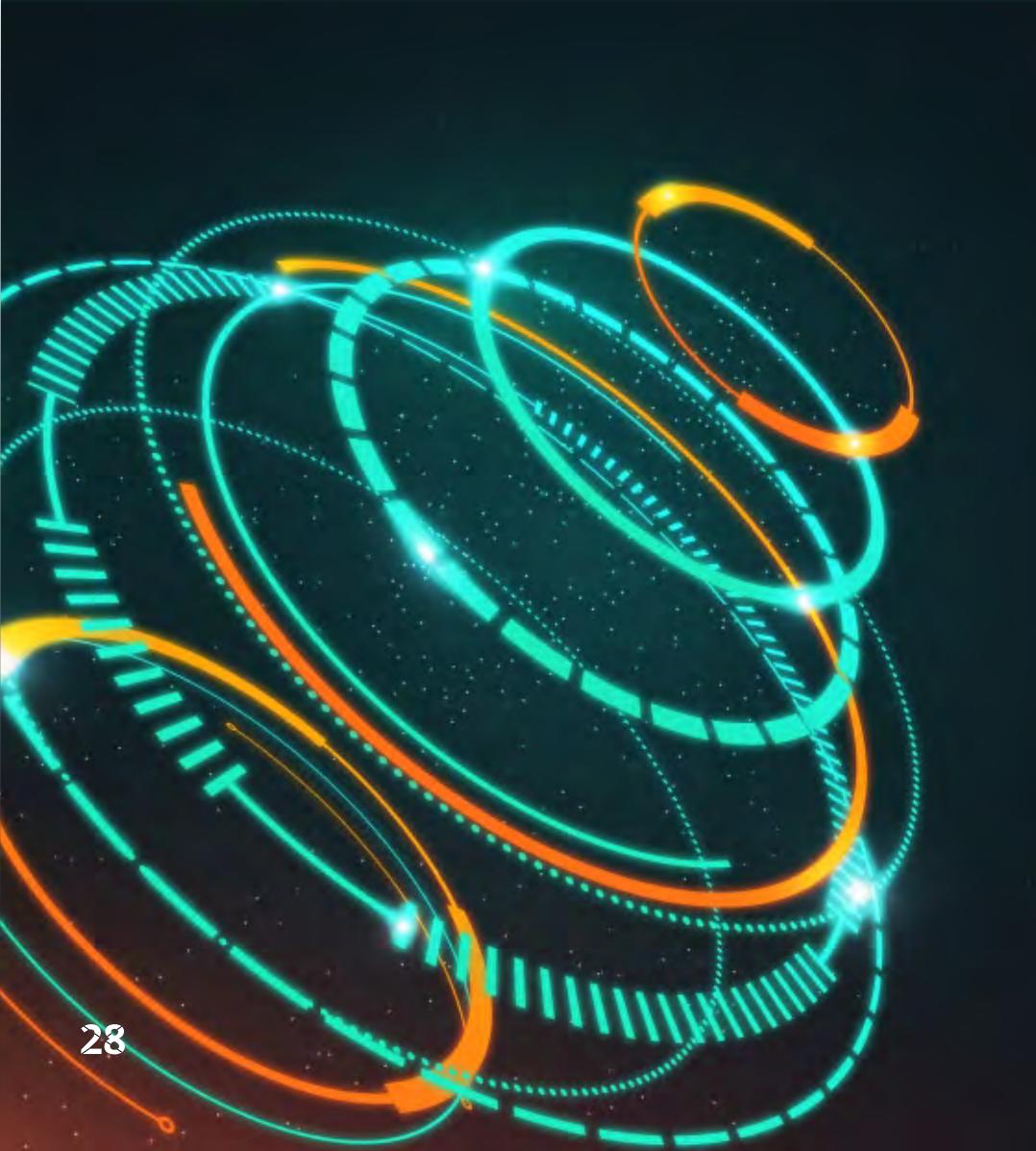
MoU between C-DAC and IGIMS



C-DAC and the Indira Gandhi Institute of Medical Sciences (IGIMS), a prestigious medical institution in Patna, have signed a Memorandum of Understanding (MoU) to collaborate on research and development projects in the healthcare sector.

EVENTS







3rd SemiconIndia futureDESIGN DLI Roadshow @ IIT Delhi organised by C-DAC Noida



Shri. Rajeev Chandrasekhar, Hon'ble Minister of State for Electronics & Information Technology and Skill Development & Entrepreneurship, Govt. of India was the Chief Guest



Digital India Dialogues hosted by C-DAC Mumbai



Hon'ble Union Minister of State for Electronics & IT and Skill Development & Entrepreneurship, Shri. Rajeev Chandrasekhar, held Digital India Dialogue - Consultation on Principles of Digital India Act (DIA) in Mumbai

BACKEND SQUAD



SHARED IT SERVICES (SITS)

As a part of SITS, C-DAC has identified e-Office: e-Mulazim web application, Integrated Human Resource Management System (iHRMS), E-mail services, Cloud services & Project Data Management System (PDMS) and shall be ported on C-DAC Cloud. As of now e-Office (e-Mulazim Web Application) has been rolled out on the C-DAC Cloud, as an integral component of Shared IT Services (SITS). This deployment followed the official launch led by the Director General on May 22nd 2023. Presently, the system is operational and available for use across all C-DAC centers and majority of C-DAC centers have commenced utilizing the application for processing e-files.

CISO DESK

ISO 27001 is being implemented in all centres of C-DAC through office of Chief Information Security Officer (CISO). As a part of the same, various activities are being carried out:

- Information Security Management System: All centers are in the process of RISK Assessment of their ICT Assets
- Cyber Crisis Management: Comprehensive Cyber Crisis Management Plan, including components such as Detection, Containment, Response, and Recovery, is currently in the process of development.
- Cyber Security Awareness Trainings: Trainings have been conducted at Hyderabad, Kolkata, Delhi & Thiruvananthapuram centres. As a part of Cyber Jaagrookha Diwas, a webinar has been conducted Dark Web and its Frauds.





INSPIRING INSIGHTS ON NEW FRONTIERS

NATIONAL SUPERCOMPUTING MISSION AND C-DAC'S EXASCALE ROADMAP

In 2015, Ministry of Electronics and Information Technology (MeitY) and Department of Science & Technology (DST), both under Government of India, announced a "National Supercomputing Mission" (NSM), an ambitious seven-year program, worth \$730 million (Rs. 4,500 crore) to design, develop and deploy supercomputing infrastructure at premier R&D labs in India. Whilst previously HPC systems were mostly assembled in India, C-DAC was entrusted with the responsibility of development of indigenous supercomputing ecosystem in phased manner under NSM: from "Assembly" to "Manufacturing" to "Design and Manufacturing" of HPC systems through frontier research in design and development of HPC components (HPC processor, Server, Interconnect switch, Storage, and Liquid cooling system), HPC System Software, HPC Applications and HPC Solutions and Services along with deployment and sustenance of peta-scale computing infrastructure across the country. NSM aims for complete self-reliance in the field of HPC. The systems deployed under NSM are dedicated to the scientific community (both R&D and academia) of the country.

The achievements under National Supercomputing Mission (NSM), have been as per the following:

- **Supercomputing Infrastructure:** Till date, 15 mid-range and high-end systems with total compute power of 24 PF capacity have been commissioned under Phase-1 and Phase-2 of NSM. More than 6500 users including 800+ PhD students from more than 120 institutes across the country are using the NSM systems. These users have published more than 850 reported publications with the help of - systems deployed during last 3 years. Under Phase-3, 10 more systems are planned to be deployed with compute power of 40 PF (with largest 20 PF national facility at C-DAC) making total compute capacity of 64 PF available under NSM.
- **Applications Development:** Applications development in the domains of Genomics, Drug Discovery, Urban Modelling, Early Warning System for Flood Forecasting, Seismic Data Analysis for Oil & Gas exploration, and Telecom network optimization have been taken up in consortium mode involving R&D and domain specific user agencies of governmental organizations.

Sanjay Wandhekar, Senior Director,
HoD
HPC Technologies



- R&D for indigenization and exa-scale readiness: Various supercomputing subsystems (Rudra server, Trinetra interconnect, Storage, system software stack, cooling system) have been indigenously designed and developed. Indigenous server "Rudra" is being manufactured by Indian EMS vendor thus creating supercomputing ecosystem in the country. Development of indigenous AUM HPC processor (India's own processor) has also been initiated.
- Human Resources Development: More than 19000 personnel have been trained till date in various aspects of HPC. This includes both computer science and non-computer science professionals.

EXASCALE ROADMAP

- It is time to target NexGen Supercomputing Mission - NSM 2.0 to design, develop and deploy next generation of supercomputers with exascale performance in next 5-8 years and prepare for Zettascale performance systems to assist India to become 'Atmanirbhar' in supercomputing and design and deploy India-specific applications with societal impact in climate modeling, weather forecasting, early warning for flood prediction, drug discovery, seismic prospecting, material research, water and energy security and so on:
- Due to large number of physical processes, their complexity and high dimensionality of Earth System, the resolution of climate model is limited by available computational power. Km-scale models allow an explicit representation of processes such as damages from wind gusts, or hail formation or orographically influenced deluges. Such scales begin to capture interaction of climate with urban landscapes or water ways with its sea-walls or levies. The compute requirement at Ministry of Earth Sciences is assessed at 500 petaflops by 2030.
- Microsecond simulation of a system containing millions of atoms needs exascale computing systems. Innovative drug-related computational genomics, proteomics, network interaction, and drug design technologies demand deployment of massive HPC resources.
- Since 1994, the floods have affected more than 2.5 billion people. Lately, the floods are occurring frequently, lasting longer, and significantly impacting national economy. To build adequate resilience, there is a need for early warning system for every river basin with improved 2D/ 3D flood forecasting simulations at few tens of square meter resolution.



- Predictive understanding of complex power generation systems and engines by computational modelling will reduce construction and operations costs, optimize performance, and improve safety. Exascale systems will make possible new approaches to quantifying uncertainty of safety and performance engineering.
- With more data and multi-scale modelling using exascale computer systems, it will be possible to have a more accurate picture of local water cycle to aid in agricultural planning. It will be easier to simulate hydrology-driven biogeochemical interactions from bedrock to canopy, along significant lateral gradients, and across terrestrial and aquatic interfaces.

AI-ML plays an increasingly greater role in many applications. An emerging area is to develop AI-surrogate physics models. For complex physics problems, traditional solutions run CFD models using massive datasets. Physics-based modelling approach is less biased than data driven models using AI-ML, since it is governed by the laws of nature. However, physics-based models are prone to numerical instability, are computationally demanding, can have huge errors owing to uncertainty in modelling and inputs, and lack of robust mechanisms to assimilate long term historical data.

While mirroring of a physical object with a virtual object by simulation-based engineering has been around since NASA began using numerical simulation for comparing the results to ground-based physical models, Digital Twins have come to prominence during confluence of HPC and AI-ML. They are digital replica of a living or non-living physical entity, such as human body, a product or a planet. They provide custom-made access to high-quality information, services, models, forecasts and visualization. They need power of supercomputers for integration of continuous observation, modelling and high-performance simulation, delivering highly accurate predictions of future developments in different application areas (weather, agriculture, medicine, manufacturing, etc.). For predicting extreme weather events, 'Digital Earth' is being developed by consortia of labs from various countries.



**HIGH
PERFORMANCE
COMPUTING
FACILITIES**

FUTURE SYSTEMS

The future systems with exascale performance and beyond are being planned to deliver high performance with lower energy consumption while contributing to the realization of a carbon-neutral and sustainable society. They will be judged with 'operations per watt'. Large datasets, high bandwidth and data movement between compute and memory consume substantial amounts of memory access power. Also, data movement among processors through communication network consumes lot of power. There is a need to holistically address all elements across computation, communications, and memory to achieve energy efficient, but high-performance systems. Other challenges include interconnecting large number of nodes using high bandwidth network with sub-microsecond latencies -using efficient network topology and routing algorithm, resource management of such a large system, fault tolerant execution of applications on large number of nodes for longer periods considering MTBF of components of the system, scaling of applications across thousands of nodes and extracting optimal performance, storage and I/O performance scale in proportion to the compute power increase, etc.

KEY DEVELOPMENTS TO BUILD EXASCALE SYSTEM ARE

The future systems with exascale performance and beyond are being planned to deliver high performance with lower energy consumption while contributing to the realization of a carbon-neutral and sustainable society. They will be judged with 'operations per watt'. Large datasets, high bandwidth and data movement between compute and memory consume substantial amounts of memory access power. Also, data movement among processors through communication network consumes lot of power. There is a need to holistically address all elements across computation, communications, and memory to achieve energy efficient, but high-performance systems. Other challenges include interconnecting large number of nodes using high bandwidth network with sub-microsecond latencies -using efficient network topology and routing algorithm, resource



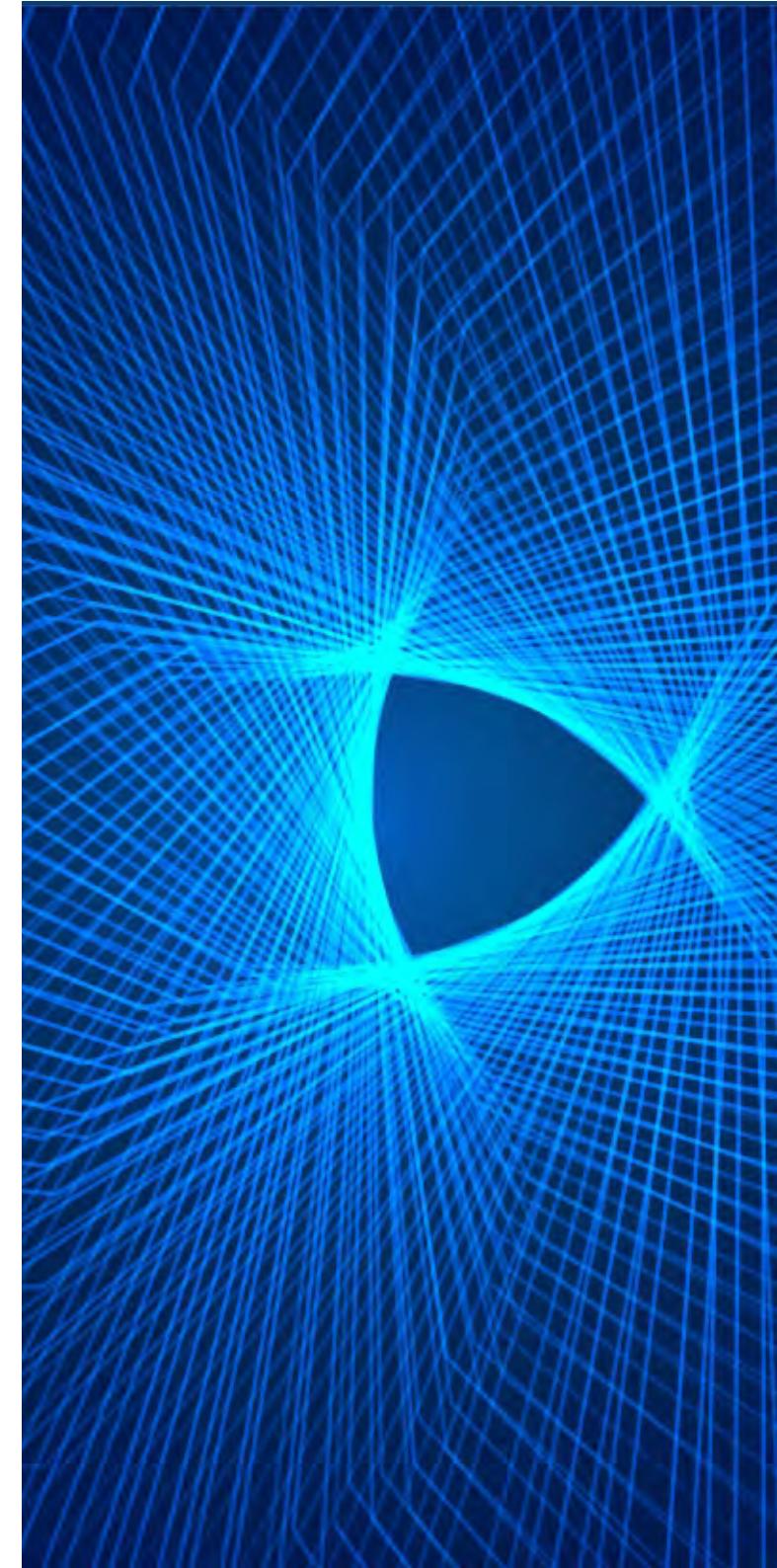
management of such a large system, fault tolerant execution of applications on large number of nodes for longer periods considering MTBF of components of the system, scaling of applications across thousands of nodes and extracting optimal performance, storage and I/O performance scale in proportion to the compute power increase, etc.

- Development of indigenous HPC processor, Servers, High-speed inter-connects, Storage system, System software stack, middleware and high-end applications by customization of existing codes in open source through collaboration to extract optimal performance on a range of architectures.
- Design and development of green technologies like liquid cooling to check the increasing demand on power and cooling is another challenge.

Many of these are already being developed in the current National Supercomputing Mission (NSM) and will be upgraded as per the requirement.

Considering above requirements, various indigenous technologies and sub-systems of Exascale Supercomputers are planned to be developed under the proposed NSM 2.0. Considering challenging and need for development of state-of-the-art technology, it is proposed to involve mandatory participation of industry for success of the program.

- **Indigenous HPC Processor** – Under NSM, development of 96 core AUM processor has been initiated and is expected to be available by 2025-26. Architecture of AUM is designed keeping in mind the requirements of HPC applications, like best bytes/Flop ratio in terms of memory bandwidth and I/O bandwidth. AUM will use HBM3e memory along with 8 channel (64 bit) DDR5 memory, PCIe5 and CXL interfaces to cater to this requirement. To continue momentum and for further high-end requirements, RISC-V based HPC Processor with competitive performance and technologies is proposed to be developed.



- **Indigenous HPC/ AI Accelerator:** Considering the requirement of power efficient systems and the requirement of accelerators for AI-ML like workloads, it is proposed to develop Accelerator based on many core RISC-V architecture for targeting both HPC and AI-ML workloads.
- **Rudra series of Servers:** Next generation of Rudra series servers based on AUM processor and latest industry leading processors from Intel, AMD and NVIDIA are proposed to be developed. - A range of Rudra servers shall be designed to cater to the HPC requirements like, high memory bandwidth, local Flash based NVME SSDs, Dual socket high core count processors, support for multiple PCIe5/CXL based high bandwidth low latency networks, CXL based memory expansion, support for multi GPU/ accelerator from industry and indigenous accelerator, secured boot and firmware support, high density 1U form factor with liquid cooling, centralized efficient, redundant and managed DC power supplies, and efficient engineering to support high dense and manageable large HPC system.
- **Trinatra HPC Network:** Trinatra is high bandwidth, low latency network designed to scale to 10,000 nodes using switchless network. Currently a 10-ports each with 200 Gbps speed is being developed. Earlier generation supports 100 Gbps, 6 links with 3-D torus topology. Continuing the momentum, next generation Trinatra network is proposed to be developed catering to higher bandwidth requirement, scaling to large number of nodes and cache coherency with the processor using CXL based interfaces or tightly integrating with indigenously developed processor. This will allow more efficient and high-performance communication which results into highly scalable application performance on massively-parallel architectures.
- **Exascale Storage:** Exascale level systems will require the convergence of storage technologies including traditional PFS, data analytics, and object-based storage for



Rudra



Trinatra

newer workloads. Distributed Asynchronous Object Storage (DAOS) kind of converged storage platform based on Flash will best suited for the exascale system. It is proposed to develop such exascale storage based on Rudra storage server which can scale to terabytes/ sec bandwidth and exabytes capacity.

- **System Software Eco-system:** Complete understanding and control of various components of software stack are essential for seamless and efficient working of exascale system with 10's of thousand nodes with 10's of cores/ node and other networking equipment. Starting from firmware like BIOS, BMC software, boot loader, secure boot requirement to programming environments and high-level software frameworks to execute applications are to be either developed or are to be derived from open-source software by porting/ customizing as per the architecture of the system. Resource and system management tools and software is another challenging requirement for such large systems. It is proposed to develop an indigenous software eco-system based on open source tools and technologies by customizing as per requirement and complimenting with tools and software developed, where necessary to achieve the final goal.

• Exascale System:

- An exascale system is proposed to be built based on indigenous technologies developed with more than 500 Peta Bytes of high bandwidth storage. The CPU v/s GPU/ accelerator ratio for this system shall be proposed based on the application requirements. The system architecture is to be worked out considering latest technologies and trends, application requirements and power requirement. Engineering of the system and data centre building is going to be state of the art and is expected to be challenging job. The system shall use liquid cooling technologies for better power efficiency.
- In summary, our proposed Exascale Roadmap is very exciting, challenging and ambitious, but achievable in a mission mode with active involvement of industry from the start







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