SERB Fund for Industrial Research Engagement (SERB- FIRE)

Intel Relevant Research Problems (IRRP) - Request for Proposals (RFP)

The Scheme for funding Industry Relevant R&D (IRRD) of SERB aims to utilize the expertise available in academic institutions and national laboratories ("academic partners") to solve industry specific problems for larger benefit of society. The Program titled 'Fund for Industrial Research Engagement (FIRE)' under IRRD supports ideas that address well-defined problems of industrial relevance in project mode. SERB signed partnership agreements with a few selected industries including Intel Technology India Private Limited (Intel India). Funding support by SERB and Intel India shall be on equal basis of 1:1 ratio for projects jointly executed by academic partners and Intel India under the program.

R&D proposals are solicited from scientists in the following specified research themes.

1. **Next-generation AI/ML technologies for autonomous systems**
2. **Center for CPU-Centric Server Systems (C3S2)**
3. **Computational approach in molecular pathway understanding for multiple convergent diseases using multimodal biological network and knowledge graph-based analysis**
4. **Integrative Proteomic and Imaging based Computational Playbook to Develop Novel Antiviral Therapeutics that Target Host Proteins involved in Single-Stranded RNA Virus Replication**
5. **Development of Novel Machine Learning Framework for Medical Images by replicating Radiologist Cognition**
6. **Graphene- Based Integrated Heat spreader with thermal conductivity>3000W/m-K**
7. **Automated reasoning assisted Formal Verification**
8. **Making the laptop the teachers aid of choice in the classroom of the future**
9. **Personalization of PC (P2C): User behaviour data assisted next generation PC experience for confidential and secured personal computing**
10. **Client devices user experience enhancements through telemetry and data analytics**

Illustrations on the problem statements under each theme will guide the prospective investigators to align and sharpen their proposals. Accordingly, the Investigators are requested to go through the details carefully before submitting the proposal.

IRRP No. 1: Next-generation AI/ML technologies for autonomous systems

Problem Statement

To devise a repository of algorithms and next generation AI/ML technologies validated in simulation and on AI based system implementation for applications including industrial automation, last mile delivery and telerobotics.

Research Vectors (RV)

- RV1: Advanced AI/ML technologies for enabling perception and data analytics
- RV2: Advanced technologies for enabling infrastructure and autonomous navigation in dynamic environments
- RV3: Advanced AI/ML technologies including learning from demonstration (LfD), human intent prediction and knowledge harvesting for applications in telerobotics

  {*RV1 and RV2 are targeted to be completed mostly in the first two years. RV3 will be taken up from third year onward. This also makes sense logically as many technologies enabled in RV1 and RV2 will be re-used in RV3*}.

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IRRP No. 2: Center for CPU-Centric Server Systems (C3S2)

Problem Statement

The strategic research objective of this call is to place the CPU again at the center of a modern server holistically synergizing CPUs, heterogeneous accelerators, and memories through novel co-design down the stack spanning system software, architecture, and microarchitecture. The overarching goal of the research is to enable a 10x performance increase, and a 10X-50X performance-per-watt and performance-per-TCO-dollar leap over existing server architectures while offering significantly better programmability, flexibility, and scalability for future datacenters.

Research Vectors (RV)

- RV 1: Applications and Workloads: Full-stack characterization of state-of-the-art DC applications, build representative DC benchmarks; guide rest of the RVs
- RV 2: Novel Datacenter core architectures: Novel latency & throughout optimized CPU architectures designed ground-up for highly threaded large code footprint WLs, research core uarch/ISA goodness beyond DSA/IPU style solutions
- RV 3: TeraByte (TB) scale Memory Hierarchies: CPU-OS co-designed TB-scale Virtual Memory, virtualized TB-scale heterogeneous (DRAM/HBM/NVM) tail latency aware memory hierarchies, compression, highly programmable CPU-centric Near-Memory-Processing architecture for PnP leap-ahead
- RV 4: CPU-centric Accelerator Ecosystem: Seamless shared-memory based CPU-centric HW-SW co-designed accelerator ecosystem enabling tight orchestration of workloads on heterogeneous accelerators, drop-in disaggregated Processing-in-Memory

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IRRP No. 3: Computational approach in molecular pathway understanding for multiple convergent diseases using multimodal biological network and knowledge graph-based analysis

Problem Statement

Computational method to systematically search for convergent disease pathways: an approach to computationally predict and experimentally study interconnected genes that are causal for two specific set of neurological diseases that affect us at different stages of our lives: Autism Spectrum Disorders (ASD) resulting from errors in neurological development of the embryonic brain, and Neurodegenerative Diseases (ND) resulting from accumulated errors in the aging brain.

Research Vectors (RV)

- RV1: Mine the existing knowledge base of genes, gene regulatory, metabolic or other biomolecular interactions dysregulated in ASD and ND using computational network methods to search for different subsets of interconnected genes (gene subnetworks representing molecular pathways) that are implicated in both diseases; and validate them in *silico* using known disease genes/pathways.
- RV2: The resulting gene subnetworks supported by genetic variants of both diseases should then be experimentally queried for its causative role in neurological deficits using various cutting- edge technologies, such as human pluripotent stem cells (hPSC), CRISPR-Cas9 genome editing, light-sheet microscopy, spatial transcriptomics apart from Zebrafish animal models with CRISPR/Cas9 mediated gene editing to perform behavioural studies.
- RV3: Integrative analysis of the resulting multi-modal (transcriptomic, microscopy and behavioural) data in stem cell and animal models should be used to test for (validate) definitive causal connections between the candidate (known) genes and the disease manifestations.

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IRRP No. 4: Integrative Proteomic and Imaging based Computational Playbook to Develop Novel Antiviral Therapeutics that Target Host Proteins involved in Single-Stranded RNA Virus Replication

Problem Statement

Identifying the unique and conserved host proteins and unravelling the mechanisms that are utilized by single stranded RNA viruses for inclusion body formation and replication towards developing antiviral therapeutics.

Research Vectors (RV)

- RV1: To investigate the mechanism by which methyltransferase mediates IB formation in RNA viruses.
- RV2: To test if small molecule inhibitors of methyltransferase activity prevent RNA viral replication in animal model using Sendai virus.
- RV3: To confirm if the conserved proteins (eg: methyltransferases) are present in IBs of human pathogenic virus (CHPV, RSV, Dengue and Covid19) and to assess the impact of inhibiting its activity on viral replication.
- RV4: To generate novel in vitro imaging based assays to screen for novel compounds that targets replication factories for human pathogenic virus.

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IRRP No. 5: Development of Novel Machine Learning Framework for Medical Images by replicating Radiologist Cognition

Problem Statement

To develop a machine learning framework which suitably employs expert cognitive processes while retaining the flexibility of the deep learning, "automated learning" paradigm.

Research Vectors (RV)

- RV1: Expert Cognition Neural Code - Plan to utilize insights from a recent breakthrough in face recognition
- RV2: Expert Cognition Scale Up: Firstly, this would demonstrably develop a framework where the respective advantages of expert cognition and machine "cognition" can be combined.
- RV3: Compute Optimization: Current machine learning tools for medical diagnosis require large resources for training as well as prediction.
- RV4: Framework: Finally, and most importantly, it would allow us to develop a full-fledged application and framework where it is possible query the machine learning system and obtain expert-understandable results -- an ability which is completely missing now and lies at the heart of current Artificial Intelligence research.
- RV5: Explainability and Robustness: Explainability will arise naturally from this approach as the network is guided to learn features/landmarks pertinent to the diagnosis.

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IRRP No. 6: Graphene- Based Integrated Heat spreader with thermal conductivity greater than 3000W/m-K

Problem Statement

Identify at what impurity/defects level we will be in a position to achieve thermal conductivity of 3000-4000W/m-K.

{Preferred minimum number of layers in graphene is 10+ but not must. Preferred approaches are both simulation and measurement}

Research Vectors (RV)

- RV1: Define the strategy for problem solving. Simulation + measurement or simulation or measurement.
- RV2: Complete analysis of thermal conductivity of monolayer pure graphene to generate a base line.
- RV3: Identify any bond breaking issues in while handling temperatures in the range of 100-250 ^{o}C
- RV4: Add impurities in steps in simulations to see at what point you can achieve 3000-4000W/m-K.

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IRRP No. 7: Automated reasoning assisted Formal Verification

Problem Statement

How to achieve faster closure to justify formal properties. As the design complexity increases, majority of the properties remains un-justified.

Research Vectors (RV)

- RV1: How to use automated reasoning in formal verification

  {*Any open formal verification tools like FORTE, NuSMV, Z3 solver or Breach solver etc, can be used for experiments. One can also use Industry standard commercial tools like JASPERGOLD/VCFORMAL etc.*}

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IRRP No. 8: Making the laptop the teachers aid of choice in the classroom of the future

Problem Statement

Traditional laptop is not the ideal machine for educational content creators – the device "lacks" many features starting with high resolution camera, digital writing pad and on top, most of the machines have small screens that make it impossible to include more than 25 students in a single voice call. Similarly, traditional classrooms allowed for a direct F2F interaction between teacher and student that allowed the teacher to moderate content flow based on how fast the students can absorb. This connect is missing and as a result, teachers are not able to get as to how many of the students actually followed the content delivery

With the next generation of teaching aids based on e-learning picking up, research is needed to identify new usages and use cases that will keep the laptop relevant and desirable in this highly lucrative market. This research will also aim at identifying new set of sensors and technology that will make laptops more effective, equitable and affordable to both teachers as well as for students.

Research Vectors (RV)

- RV1: New hardware capabilities for the teacher's PC – Additional companion display with multiple camera feeds, binaural audio, Intelligent collaboration, new sensors and digitizers like doodle pad, spatial pen/ stylus, ergo sensors (posture, ergo assessment etc) and the like.

- RV2: New Software algorithms that apply advanced processing techniques and AI to deduce ergo of students and teachers, attentiveness assessment, engagement assessment of students etc.

- RV3: Equitable: Today a big population use their parents' smartphones to connect, primarily because they are not able to afford laptops. Can AI be used to enhance standard low cost device capabilities that can make it more practical for students to use? Some examples could be the use of AI to enhance Audio and speech so low cost speakers and microphones can extract more audio range (classroom) that makes it suitable for students.

- RV4: Multi room experience. Break out room support in zoom and others is not very engaging. In a school context, one group would be able to hear other groups to some extent, and they can learn from the other groups' questions to the teacher. Here you need to switch to a room or come back to class. It may actually be useful for the students to hear other groups' audio in a different channel, lower volume or as voice-to-text.

- RV5: New sensors and algorithms that can capture students posture using camera and analytics to ensure students are getting the right level of stretch and exercise as desired by the PET teacher.

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IRRP No. 9: Personalization of PC (P2C): User behaviour data assisted next generation PC experience for confidential and secured personal computing

Problem Statement

Intel will work with the research team on defining, prioritized problem statements, solution exploration, and architecture. {*Algorithms (Audio, Image, Video, Media streaming, Multiparty Teleconferencing, Graphics 2D/3D), Personalization, Security, Runtime System management (Scalable Compute)*}

Research Vectors (RV)

- RV1: Research in user and system data insight supported PC user experience or algorithm improvement should cover
    - Systematic research on identification of PC user data set generating insights
    - Developing domain specific Algorithms (ML and / or Operations research, other statistical methods)
    - Creation of consumable training data set and related methodologies
    - Feasibility and hardware & software solution for inferencing on client system
    - Solutions for privacy and confidentiality of user data
- RV2: Algorithms:
    - Efficient design and application of audio imaging, graphics sensors algorithm that can showcase new and/or improved use experience in PC usage. Demonstration through PoC
    - Efficient hardware implementation when applicable.
- RV3: Dynamic System management:

{Algorithms and PoC for scalable compute schedule policies and algorithms that scales across workloads and identification of data set required for algorithm implementation}

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IRRP No. 10: Client devices user experience enhancements through telemetry and data analytics

Problem Statement

Personal computing experience is an integral part of modern life and there is a need to continuously evolve and enhance the capabilities and user experience in this domain.

PC telemetry involves collecting the data and metrics related to (but not limited to) software application usage, battery consumption, key performance indicators (such as CPU, memory, network etc. usage), system responsiveness and encountered error conditions from the end user systems in the field. This data is becoming an increasingly important measure to assess the real-world PC usage, identify the improvement areas and help in enhancing the user experience in the next gen devices

The area of research is broad. The idea is to holistically understand the actionable insights that come out of the telemetry data using analytical research. This in turn will enable Intel to develop out-of- the-box solutions in the future of personal computing. Analytical insights from PC telemetry data can provide valuable inputs to PC design elements such as SoC (System on Chip), Hardware, Software, Firmware, Power and Performance (PnP).

Research Vectors (RV)

- RV1 - Identify the specific problem areas which can be addressed with the usual telemetry data retrieved from a PC. It should also aim to recognize additional key data points which can be collected to enhance analytics solutions based on Telemetry data aimed towards better user experience of PCs.
- RV2 - Develop optimized data models to enhance insights and make implementable recommendations for the next generation PCs. This should include development of diagnostic and predictive algorithms to find the causal and correlational effects of multivariate telemetry data on System Performance, Stability, Reliability, Responsiveness and Quality of Service
- RV3 – Identify hidden patterns in the telemetry data to characterize user personas and suggesting persona-based device offering with user behavior analytics.
- RV4 – Model the power, thermal and battery characteristics of PCs with temporal analytics on system telemetry data.

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EXPECTATION FROM THE PI/INSTITUTION

- The PI/Co-PI should have carried out projects in the theme specified and have a minimum of 5 years of experience in the domain.
- Intel India will have a Co-PI on the selected proposal.
- The projects to be identified should be at TRL 3 or above. Typical duration of the project should be 2 years with strict performance review.
- Sharing of Intellectual property rights emanating from the projects shall be determined based on the mutual discussions between the Industry Partner and the identified academic institution / investigator. An agreement (individual agreement) defining the modalities of IP sharing will be made between the academic partner and Intel India before commencement of the project.

GENERAL GUIDELINES

- Applicants [Principal Investigator (PI) and Co-Principal Investigator(s) (Co-PI(s))] should be Indian citizens. The applicant(s) must hold a regular academic/research position in a recognized academic institution or national laboratory or in any other recognized R & D institution in India.
- The funding is provided for a period of two years. The research grant is provided for minor equipment (essential), manpower, consumables, travel and contingency. "Overheads" is also be provided to the implementing institution as per prevailing norms of SERB.
- All the rights, duties and obligations pertaining to any intellectual property, profit sharing/royalty and / or related aspects shall be discussed and agreed separately in writing with the participating academic institute(s) and Intel India under definitive agreement(s), in order to enable Intel India to commercialize and benefit from the developed solutions.

	Intel India	**SERB**
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Please visit SERB online portal for more details & submission of proposals.
(www.serbonline.in)