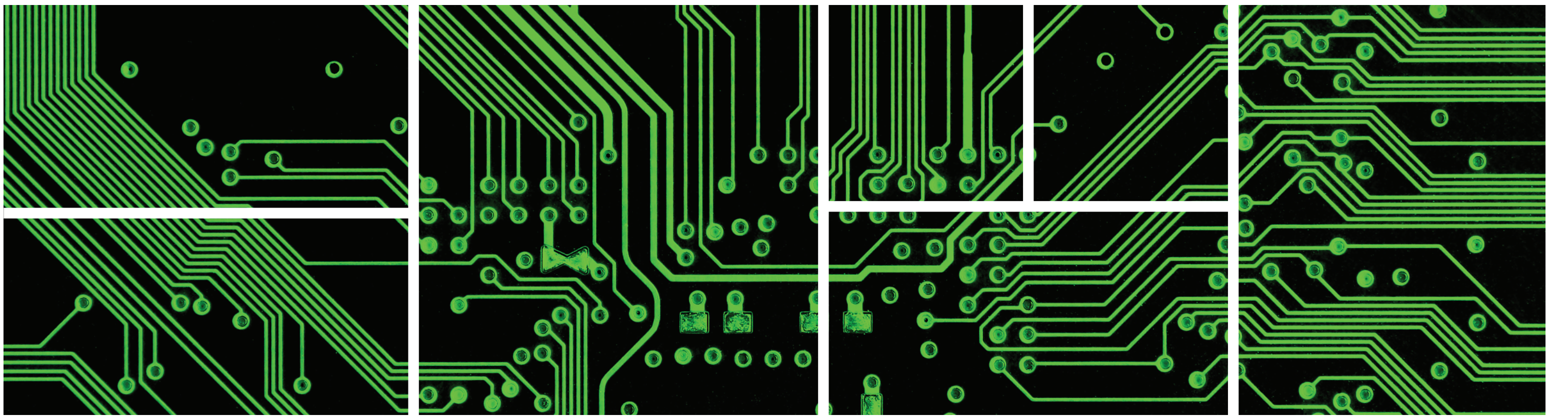
Compute/Storage Systems
Electrical & Computer Engineering



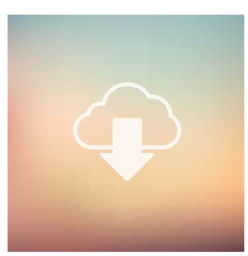
The digitally storage universe of 2013 contains 4.4 Zetta-Bytes (ZB) of information. That is 10^{21} Bytes, or one trillion modern hard disk drives. This universe will continue to expand at a rate of 40% per year for the foreseeable future, leading to a 44 ZB digital universe by 2021. At the same time, computing power has grown million-fold over the last thirty years, enabling simulation as new foundation of science at the high end while putting enormous computing capabilities into everybody's pocket.

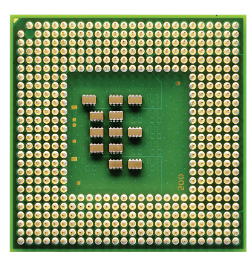
In ECE, we vertically integrate novel storage and computing technologies. The storage aspect spans from cloud storage and storage systems and storage for mobile computing to novel storage devices for computing systems, both persistent and dynamic. Our work in 3D integrated memory and computing bridges storage and computing, and enables the high aggregate bandwidth needed by our computing technologies. In the computing area we are developing novel computing techniques like hardware accelerators, non Von-Neumann computing, application-specific computing, and stochastic computing to help overcome the power wall and low arithmetic intensity, and handle manufacturing process induced uncertainty.

ECE has a long history of leadership in data storage research. The Data Storage Systems Center (DSSC) has led university research efforts in the advances in data storage devices, technology and associated signal processing to support increases in recording density of 100,000x over its period of activity.

The Parallel Data Lab (PDL) has exerted similar leadership in storage systems and large-scale infrastructures. PDL activities focus on computer systems level solutions to the problems of storing and managing vast data sets, addressing I/O bottlenecks, and handling complex data center challenges regarding efficiency, reliability, multi-tenancy, and administration.

The computer architecture lab at Carnegie Mellon (CALCM) brings together faculty, staff, and students interested in computer architecture research and education. The upcoming Memory Systems Research Center initiative aims to tackle cross-layer solutions to future memory systems from devices to architectures to applications. We focus on novel computing devices and efficient computer architectures that take advantage of emerging hardware trends like 3D integration, design uncertainty, and beyond silicon technologies, while addressing the challenges introduced by them.





Electrical & Computer ENGINEERING

Carnegie Mellon University

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ECE expertise

Storage and computing cuts across multiple centers and research thrusts: DSSC, the emerging Memory Center, PDL, CALCM, and beyond CMOS efforts. Both directions have close synergy with device development and nanofabrication. This area has a strong focus on system synthesis using innovative devices, forges collaborations with the data/network science thrust, and is home to a large computer architecture group.

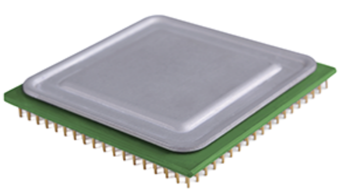
Devices and Technology (DSSC)

We are addressing the density challenges through several approaches. CMU has led academic research in Heat Assisted Magnetic Recording (HAMR) for hard disk drives (HDD) for more than a decade, and has collaborated with industry on bringing this concept to commercial reality. This technique employs new materials and new plasmonic optical write head to increase the storage density. Microwave Assisted Magnetic Recording (MAMR) is currently being evaluated by the storage industry. Active research programs on magnetic and resistive non-volatile memory complement this work on hard disk drive devices. Signal processing and coding research informed by the specific behavior of these novel devices promotes the ability to actually deploy them in a system. *Contact: Jim Bain, Jimmy Zhu*

Systems and Data Centers (PDL)

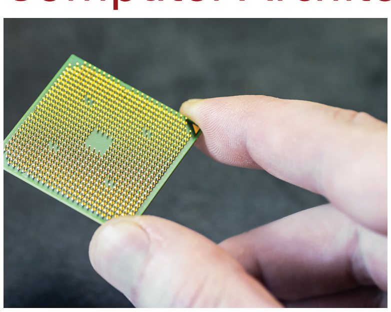
We push the frontiers of storage systems and large-scale infrastructure. Recurring themes include exploitation of new technologies (e.g., Flash and non-volatile RAM or NVM), support for emerging application domains (e.g., cloud computing and Big Data/data science), and enabling next generation scale by addressing the consequent efficiency and manageability challenges. One current hot topic is support for large-scale machine learning and other big data analytics via new database and processing/storage frameworks. Another hot topic is highly efficient and scalable metadata and key-value stores for large-scale storage and Internet services. The PDL operates private clouds with real users in CMU's Data Center Observatory (DCO), providing logs, instrumentation data, and real case studies for research.
Contact: Greg Ganger, Garth Gibson

Emerging Memory Center



We vertically integrate memory, computer architecture, and algorithm design to enable high performance power efficient computing devices that leverage current and emerging technologies. We co-optimize algorithms and systems relative to the impact of novel memory technologies like 3D integration of memory and processors and future technologies like MRAM and MLogic. We are rethinking existing memory technologies (DRAM, SRAM, flash memory) with rigorous modeling, new architectures and new applications to overcome the shortcomings of their current implementations, enabling and empowering new memory technologies (PCM, MRAM, RRAM) and new system designs for them, inventing new interfaces to enable fast and energy-efficient access to large amounts of persistent data, enabling in-memory and in-storage computation with new devices, execution models, interfaces, programming models, and applications, and enabling heterogeneous memory systems. These efforts are driven by the requirements of big data, data science, and low-power high performance devices for ubiquitous computing. *Contact: Franz Franchetti, Ken Mai, Onur Mutlu*

Computer Architecture (CALCM)



Our expertise in computer architecture spans a wide range. Computer architecture research addresses issues of power efficiency and green computing where we apply statistical learning approaches for managing power in large scale computing systems and implementing computational kernels for on-chip learning in an energy efficient manner. Another focus is on processor microarchitecture, non-Von-Neuman architectures, simulation and FPGA emulation of computer and natural or man-made systems, and tools for high-level hardware design and synthesis. A further focus is on improving programmability, reliability, and efficiency of computing devices, working across the layers of the system, from the microarchitecture to the application and on everything in between. We research the hardware/software architecture of computer systems and microprocessors so as to significantly enhance their performance, reliability, and efficiency. *Contact: James Hoe, Brandon Lucia, Diana Marculescu*