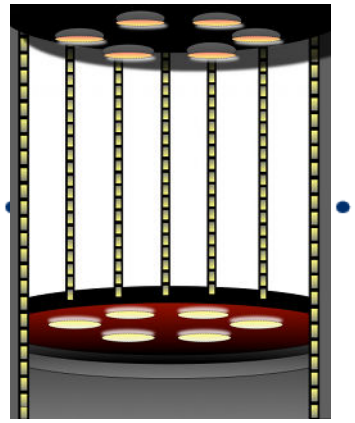
Center for Research on Intelligent Storage and Processing in Memory (CRISP)

Kevin Skadron
Harry Douglas Forsyth Professor and Chair of Computer Science

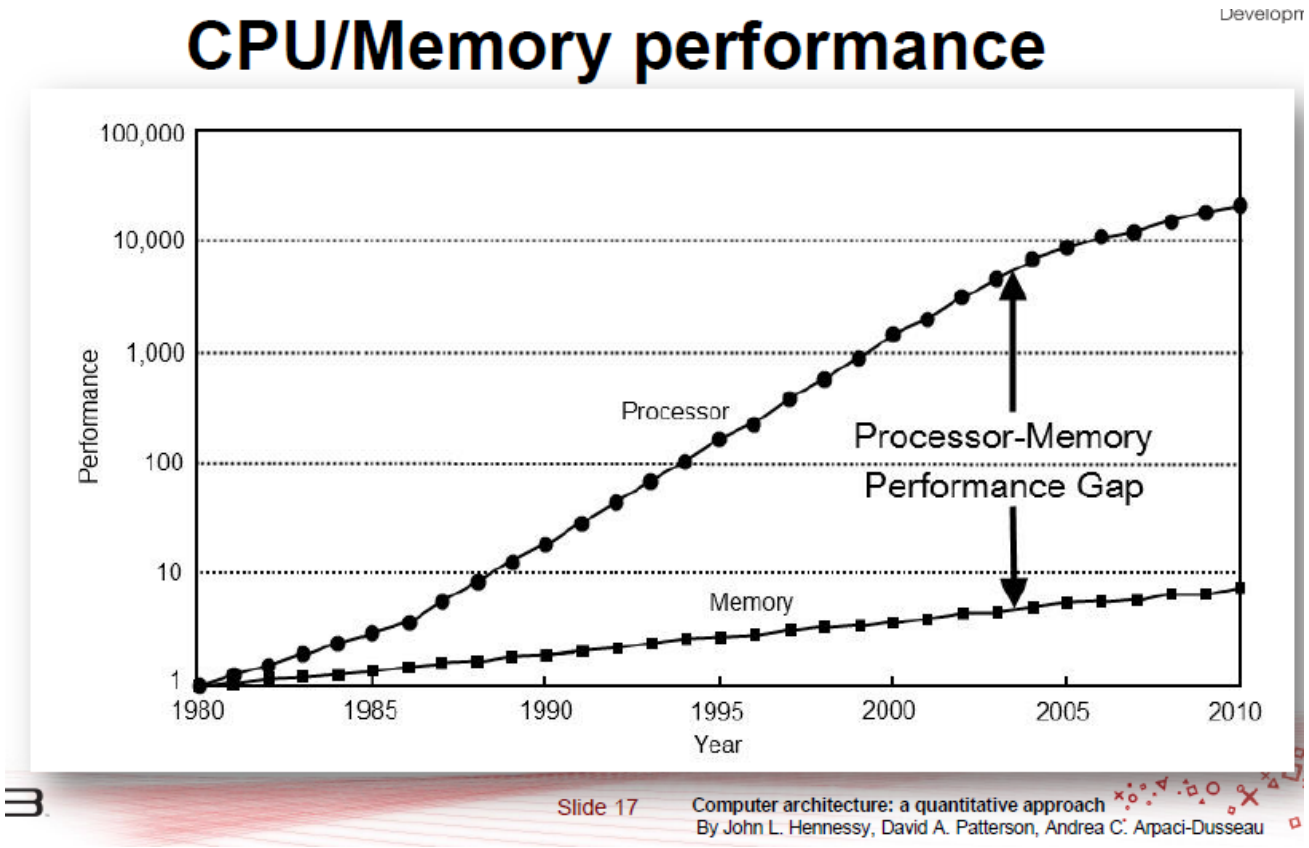
My Background

- BS in Electrical & Computer Engineering, BA in Economics, Rice ‘94
- PhD in Computer Science, Princeton *99
- UVA 1999-present
- My research journey at UVA—pushing the limits of microprocessor design
  - Power/thermal management for microprocessors
  - Early days of GPUs for high-performance computing
  - Automata processing (a form of processing in memory), CAP
  - CRISP

The Memory Wall



- First described by Bill Wulf and Sally McKee at UVA in 1994
- Processor speeds and throughputs improving faster than memory/storage
  - Memory access now requires 100s of CPU clock cycles
  - CPU stalled, waiting for memory
- Problem traces back to von Neumann architecture
  - Processor and memory physically separate
  - This has been physically necessary until recently
  - *This assumption is embedded in all aspects of today's hardware and software ecosystem*



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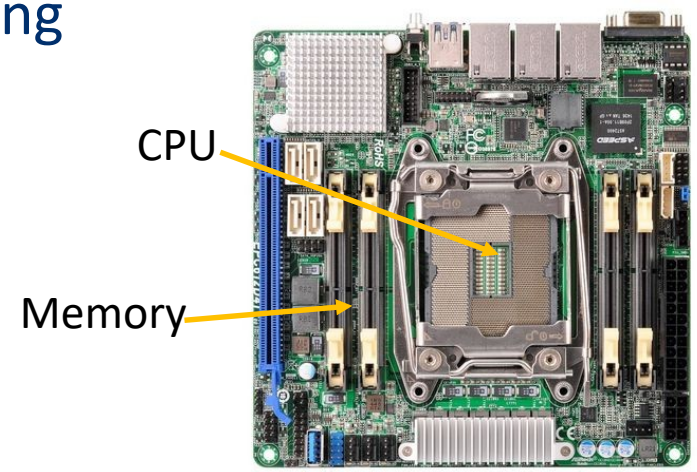
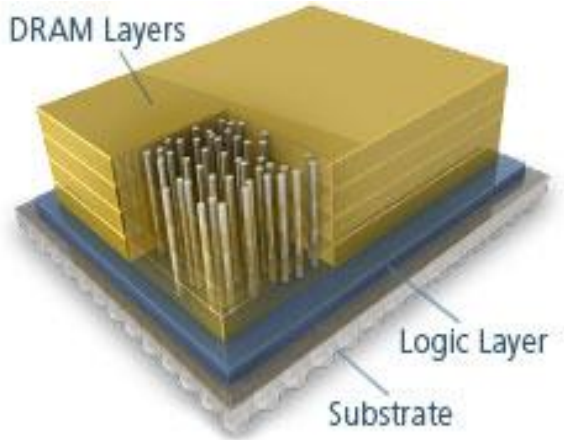
Opportunity: Tight Coupling of Processing & Memory

- Goal: break down the memory wall by embedding processing in the data
  - New hardware designs, support software, application demos
  - Grand challenge: 100X speedup
- Emerging opportunities for Near-Data Computing
  - Today's memory and storage systems have 10-100X more raw internal bandwidth than they can send to the CPU
  - 3D chip stacking, embed logic directly in memory chips, etc.
- Time is right - processor architecture changing
  - Slowdown in conventional Moore's Law, advent of accelerators
- 100X speedups would transform computing
  - Allow real-time computing on streaming big data, much deeper analysis of big data
  - Applications in medicine, national security, AI, etc.



ASRock EPC612D4I motherboard, http://www.asrockrack.com/general/productdetail.asp?Model=EPC612D4I#Specifications

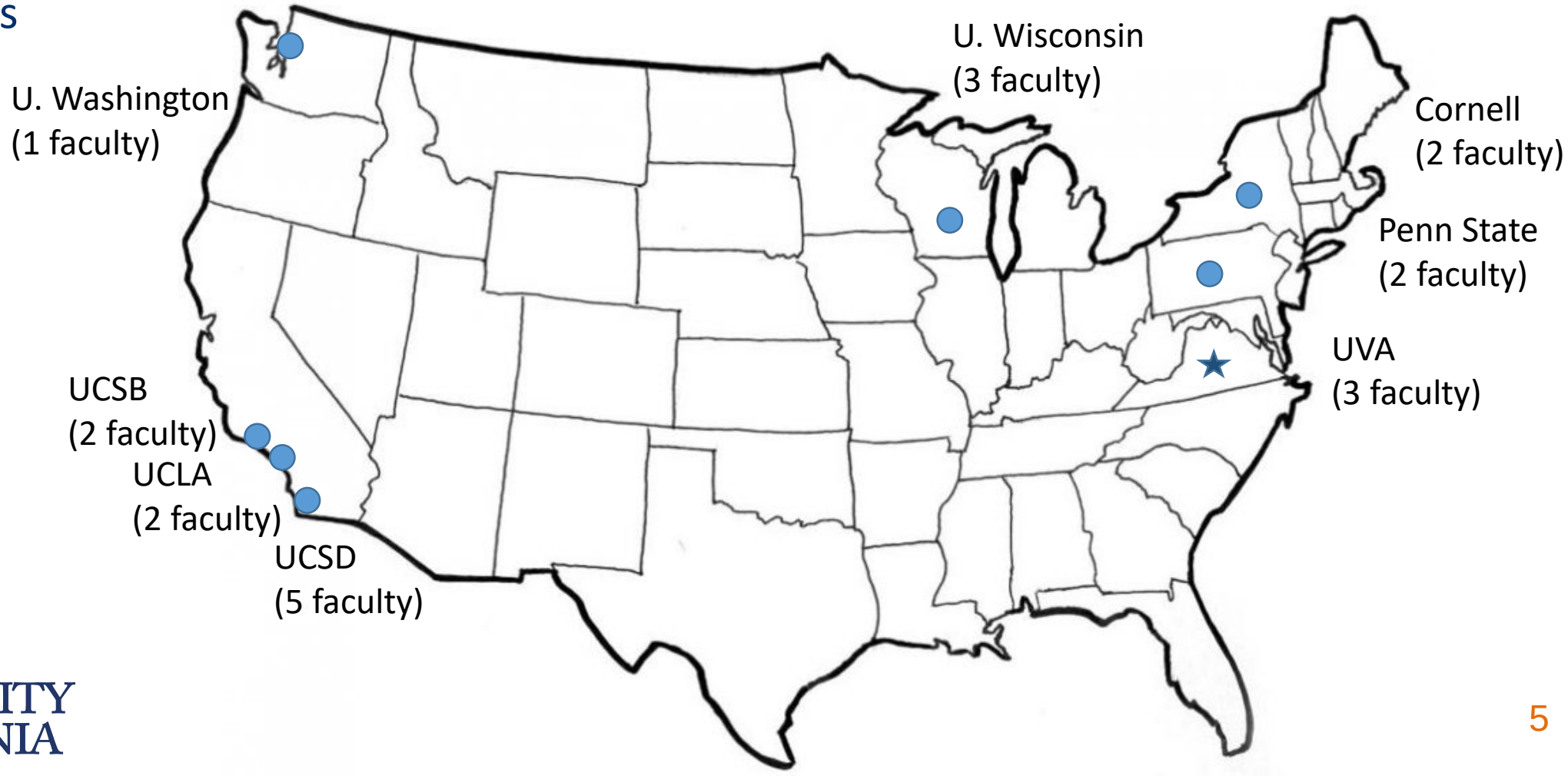


Micron Hybrid Memory Cube *www.micron.com/products/hybrid-memory-cube/all-about-hmc*

CRISP

Center for Research on Intelligent Storage and Processing in Memory

- 20 faculty so far
- 8 universities
- $27.5M, 5 years



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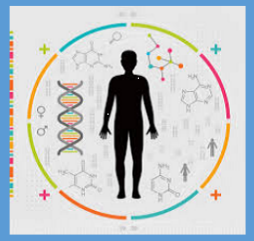
CRISP – Center for Research on Intelligent Storage and Processing-in-Memory

New Software Ecosystems and Application


Video Analytics


Precision Medicine


Cognitive Computing

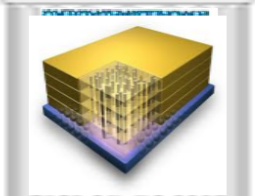
Big Data Analytics

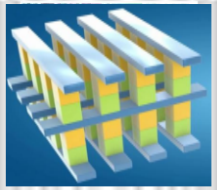
Theme 3: Scaling Applications and Making the Programmer's Life Easy

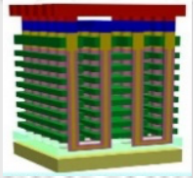
Theme 2: System Support for Massively Parallel Heterogeneity

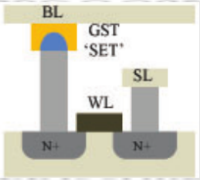
Theme 1: Hardware Support For Massively Parallel, Hierarchical Processing in Memory and Storage

Modeling | Metric-centric engineering | Hardware prototyping

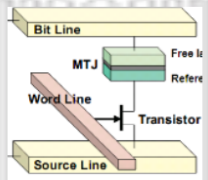

HMC


3D X-point


3D NAND

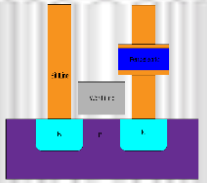


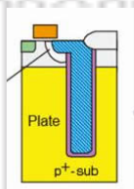
PCRAM



STT-MRAM


ReRAM


FeRAM



DRAM

Example Mature and Emerging Memory Devices

Research Questions

- What data-intensive operations do modern applications need?
- How to support these operations in hardware?
- How to manage power and heat?
- How can emerging semiconductor devices help?
- How do we create an intuitive programming model than can use the new hardware?
- How do we protect data? (e.g., security and reliability)
- How to use the capabilities in real, complex applications?

Etc….

Opportunities for UVA

- UVA is already well known in computer architecture and semiconductor devices areas
  - CRISP, plus several additional faculty and many research projects in related areas
  - No university fully covers the CRISP research space—we could take a long-term lead
    - Build an interdisciplinary lab similar to LinkLab
- Good synergy with other UVA priorities
  - CRISP's device, architecture, and power/thermal design tasks connect to the Multifunctional Materials Integration (MMI) initiative in SEAS
  - Application areas include cyber-physical systems (LinkLab), Data Science, and Engineering in Medicine
- Needs
  - Several faculty hires to fill gaps
  - Lab facilities for 3D chip integration, thermal research (would also benefit MMI)
  - Funding for 2-3 years of seed projects, and bridge support for 3-4 research scientists/postdocs, to rapidly build collaborations
  - Shared space

Thanks

- VPR office
- Pam Norris, SEAS Exec. Assoc. Dean for Research
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- Steven Arora and Kristy Hall, OSP
- Rob Merhige and Michael Straightiff, LVG

UVA Team

Kevin Skadron, Center Director, Professor, Computer Science

Samira Khan, Assistant Professor, Computer Science

Mircea Stan, Professor, Electrical & Computer Engineering

Questions?