THE COMPUTING COMMUNITY CONSORTIUM: CATALYZING AND ENABLING COMPUTING RESEARCH

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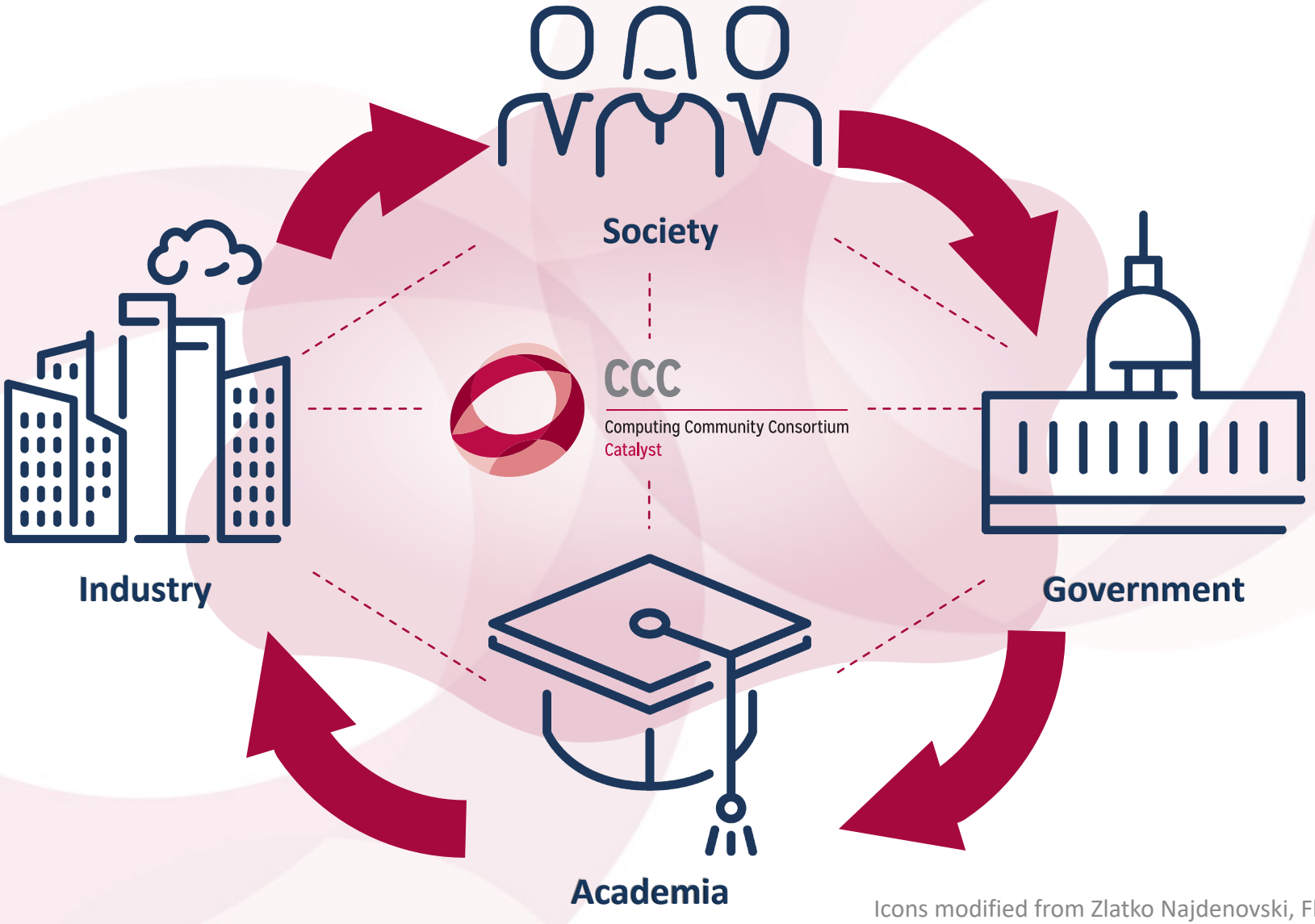
1. **What is CCC?**
2. **20th Century Computer Architecture (flip thru example)**
3. **Implications for This Workshop**

Appendix: A Vision to Compute Like Nature: Thermodynamically

CCC
Computing Community Consortium
Catalyst

THE NEED FOR AUDACIOUS RESEARCH



Icons modified from Zlatko Najdenovski, Flaticon

COMPUTING COMMUNITY CONSORTIUM

Mission: **Catalyze** the computing research community & **enable** the pursuit of innovative, high-impact research

Who

- Council – 20 members
- Chair, VC, & Director
- CCC/CRA Staff

Inputs: Bottom-up, Internal, & Top-Down

What:

- **Workshops** & Conf. Blue Sky Tracks
- Whitepapers & Social Media
- **Reports Out to Community/Government**

Talent Development

- Early Career Workshops & Participation
- Council Membership
- Leadership w/ Gov't (LISPI)

21st Century Computer Architecture

A CCC community white paper, May 2012

http://cra.org/ccc/docs/init/21stcenturyarchitecturewhitepaper.pdf

- Participants & Process
- Information & Commun. Tech's Impact
- Semiconductor Technology's Challenges
- Computer Architecture's Future
- Pre-Competitive Research Justified

White Paper Participants

Sarita Adve, U Illinois *
David H. Albonesi, Cornell U
David Brooks, Harvard U
Luis Ceze, U Washington *
Sandhya Dwarkadas, U Rochester
Joel Emer, Intel/MIT
Babak Falsafi, EPFL
Antonio Gonzalez, Intel/UPC
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Mary Jane Irwin, Penn State U *
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Christos Kozyrakis, Stanford U
Alvin Lebeck, Duke U
Milo Martin, U Pennsylvania

José F. Martínez, Cornell U
Margaret Martonosi, Princeton U *
Kunle Olukotun, Stanford U
Mark Oskin, U Washington
Li-Shiuan Peh, M.I.T.
Milos Prvulovic, Georgia Tech
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Michael Schulte, AMD/U Wisconsin
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Guri Sohi, U Wisconsin
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Josep Torrellas, U Illinois *
Thomas F. Wenisch, U Michigan *
David Wood, U Wisconsin *
Katherine Yelick, UC Berkeley/LBNL *

"*" contributed prose; "**" effort coordinator

Thanks of CCC, Erwin Gianchandani & Ed Lazowska for guidance and Jim Larus & Jeannette Wing for feedback

~$90M thru 2020 + ~$90M Expected

Exploiting Parallelism and Scalability (XPS)

PROGRAM SOLICITATION
NSF 13-507

National Science Foundation

Directorate for Computer & Information Science & Engineering
Division of Computing and Communication Foundations
Division of Information & Intelligent Systems
Division of Computer and Network Systems

Office of Cyberinfrastructure

Full Proposal Deadline(s) (due by 5 p.m. proposer's lo

February 20, 2013

Award Information

$15M on 2/2013

Approximately 20 awards of up to $750,000 for periods up t
availability of funds

Anticipated Funding Amount: $15,000,000

Prominently cites whitepaper

At the same time, a ma
technology is facing fundamental physical limits and single processor performance has plateaued. Two recent reports, "21st Century Computer Architecture" commissioned by the Computing Community Consortium (http://cra.org/ccc/docs/init/21stcenturyarchitecturewhitepaper.pdf) and the 2011 NRC report on "The Future of Computing Performance: Game Over or Next Level?" (http://www.nap.edu/catalog.php?record_id=12980) highlight this development and its impact on science, the economy, and society. The reports pose the question of how to enable the computational systems that will support emerging applications without the benefit of near-perfect performance scaling from hardware improvements. NSF's *Advanced Computing Infrastructure: Vision and Strategic Plan* (http://www.nsf.gov/pubs/2012/nsf12051/nsf12051.pdf) published in February 2012 describes strategies that address this challenge for NSF and the research community. The XPS program is part of the larger NSF CIF21 framework.

~$15M/year for XPS, SPX, and 2020+ PPoSS

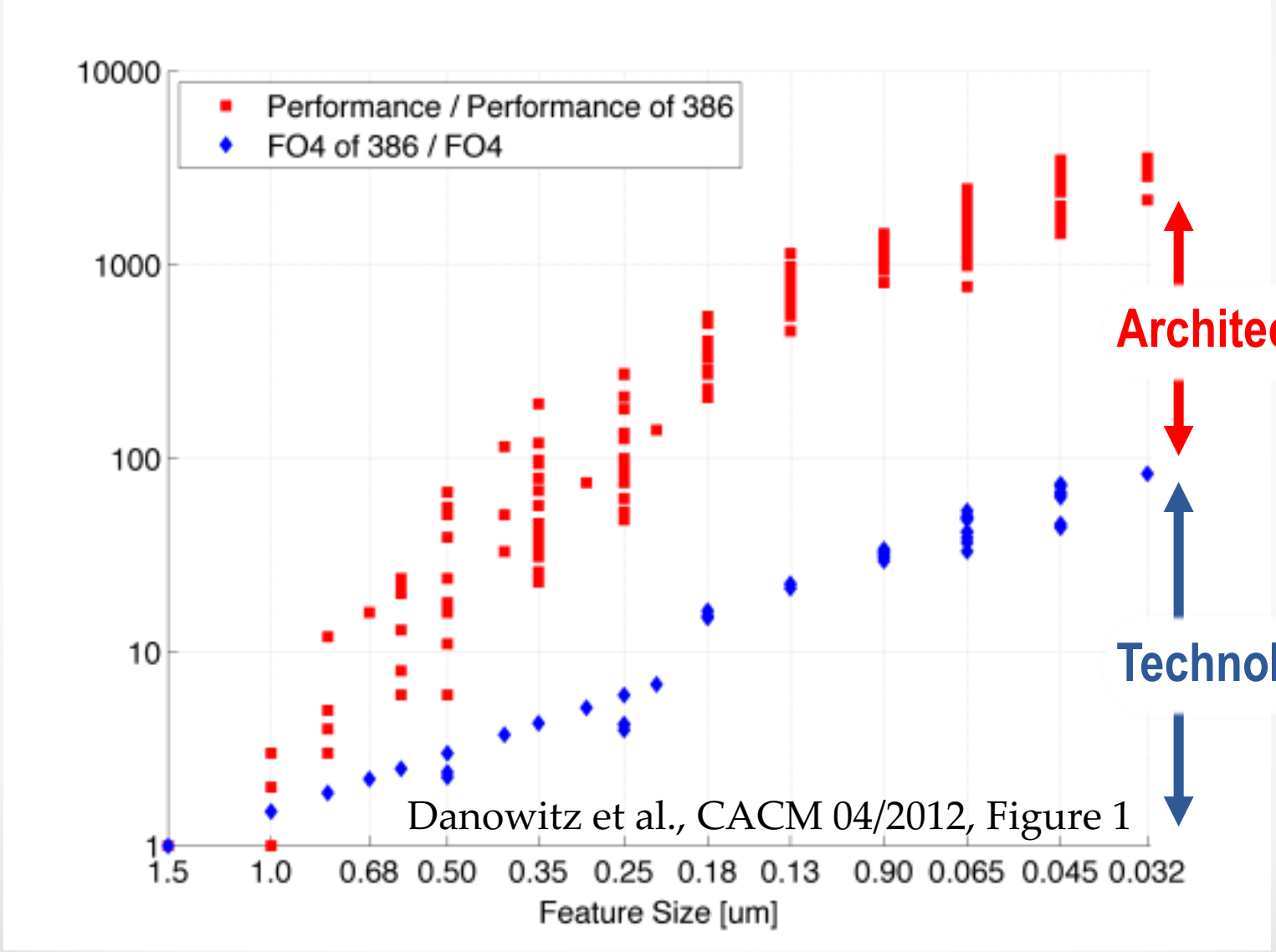
20th Century ICT Set Up

- Information & Communication Technology (ICT) Has Changed Our World
  - <long list omitted>

- Required innovations in algorithms, applications, programming languages, … , & system software

- Key (invisible) enablers (cost-)performance gains
  - Semiconductor technology ("Moore's Law")
  - Computer architecture (~80x per Danowitz et al.)

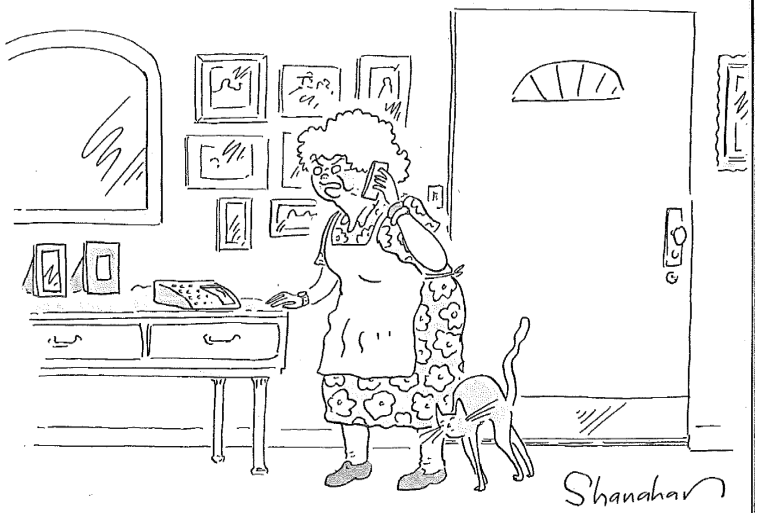
Enablers: Technology + Architecture



21st Century ICT Promises More

Data-centric personalized health care

Computation-driven scientific discovery



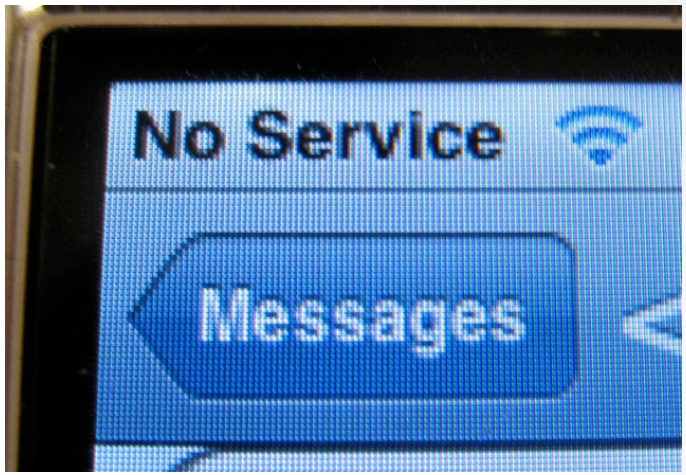
"You never call, and the federal government will back me up on that."

Human network analysis

Much more: known & unknown

21st Century App Characteristics

BIG DATA



ALWAYS ONLINE

SECURE/PRIVATE

Whither enablers of future (cost-)performance gains?

Technology's Challenges 2/2

Late 20th Century	The New Reality
Moore's Law — 2× transistors/chip	**Transistor count still 2× BUT…**
Dennard Scaling — ~constant power/chip	**Gone.** Can't repeatedly double power/chip
Modest (hidden) transistor unreliability	**Increasing transistor unreliability** can't be hidden
Focus on computation over communication	**Communication (energy)** more expensive than computation
1-time costs amortized via mass market	**One-time cost** much worse & want **specialized** platforms

How should architects step up as technology falters?

21st Century Comp Architecture

20th Century	21st Century	
Single-chip in stand-alone computer	**Architecture as Infrastructure:** Spanning sensors to clouds Performance plus security, privacy, availability, programmability, …	**Cross-Cutting:** Break current layers with new interfaces
Performance via invisible instr.-level parallelism	**Energy First** • Parallelism • Specialization • Cross-layer design	
Predictable technologies: CMOS, DRAM, & disks	**New technologies** (non-volatile memory, near-threshold, 3D, photonics, …) Rethink: memory & storage, reliability, communication	

Pre-Competitive Research Justified

- **Retain (cost-)performance enabler to ICT revolution**

- Successful companies cannot do this by themselves
  - Lack needed long-term focus
  - Don't want to pay for what benefits all
  - Resist transcending interfaces that define their products

- Corroborates
  - Future of Computing Performance: Game Over or Next Level?, National Academy Press, 2011
  - DARPA/ISAT Workshop Advancing Computer Systems without Technology Progress with outbrief http://www.cs.wisc.edu/~markhill/papers/isat2012_ACSWTP.pdf

SUCCESSFUL VISIONING ACTIVITIES

- Engage the community and relevant stakeholders
- Facilitate broad thinking with compelling examples
- Create new avenues for (interdisciplinary) collaboration
- Encourage the community to look around the corners
- Rapidly capture & synthesize ideas from the community
- Present ideas & engage possible funders and stakeholders
- Articulate needs and barriers to research impact

IMPORTANT FOR WORKSHOPS

Hegel

- Process matters: Really listen & respectively discuss

  Dialectic: *A discourse between two or more people holding different points of view about a subject but wishing to establish the truth through reasoned methods of argumentation.* ***–Wikipedia***

- Develop **compelling** story for
  - Our/your community
  - The public's representative, e.g., at agencies
  - Include, "why now?"
  - ***It is not good enough for be right, you also must be effective.***

    --Neil deGrass Tyson's Father

- **Finish:** ***"They remember you for what you finish."*** ***–Dave Patterson***
  - Draft material by week's end
  - Finish report/deck: v1 in weeks; final in a month or two
  - Visit agencies (virtually)
  - ***"The perfect is an enemy of the done."*** ***–Mike Morgan, Publisher***

MY (OUTSIDER) THOUGHTS ON RC

- In addition to important long-term goals,
  - Identify early/niche successes to sustain funding?
  - E.g., how FLASH operated in cameras before hard drives

- Is Reversible Computing a good name?
  - People think they know what Reversible means; most are wrong
  - Adiabatic may be better as people either know it (correctly) or wait for it to be defined, but it may have "slow" connotations. Accelerate Adiabatic?
  - Somehow use Recycling as it seems we are recycling energy or information to save energy end-to-end?

SOME DAY: THE HEILMEIER CATECHISM

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What is new in your approach and why do you think it will be successful?
- Who cares? If you are successful, what difference will it make?
- What are the risks?
- How much will it cost?
- How long will it take?
- What are the mid-term and final "exams" to check for success?
- Facilitate broad thinking with compelling examples
- Create new avenues for (interdisciplinary) collaboration
- Encourage the community to look around the corners
- Rapidly capture and synthesize ideas from the community
- Present ideas and engage possible funders and stakeholders
- Articulate needs and barriers to research impact

https://www.darpa.mil/work-with-us/heilmeier-catechism