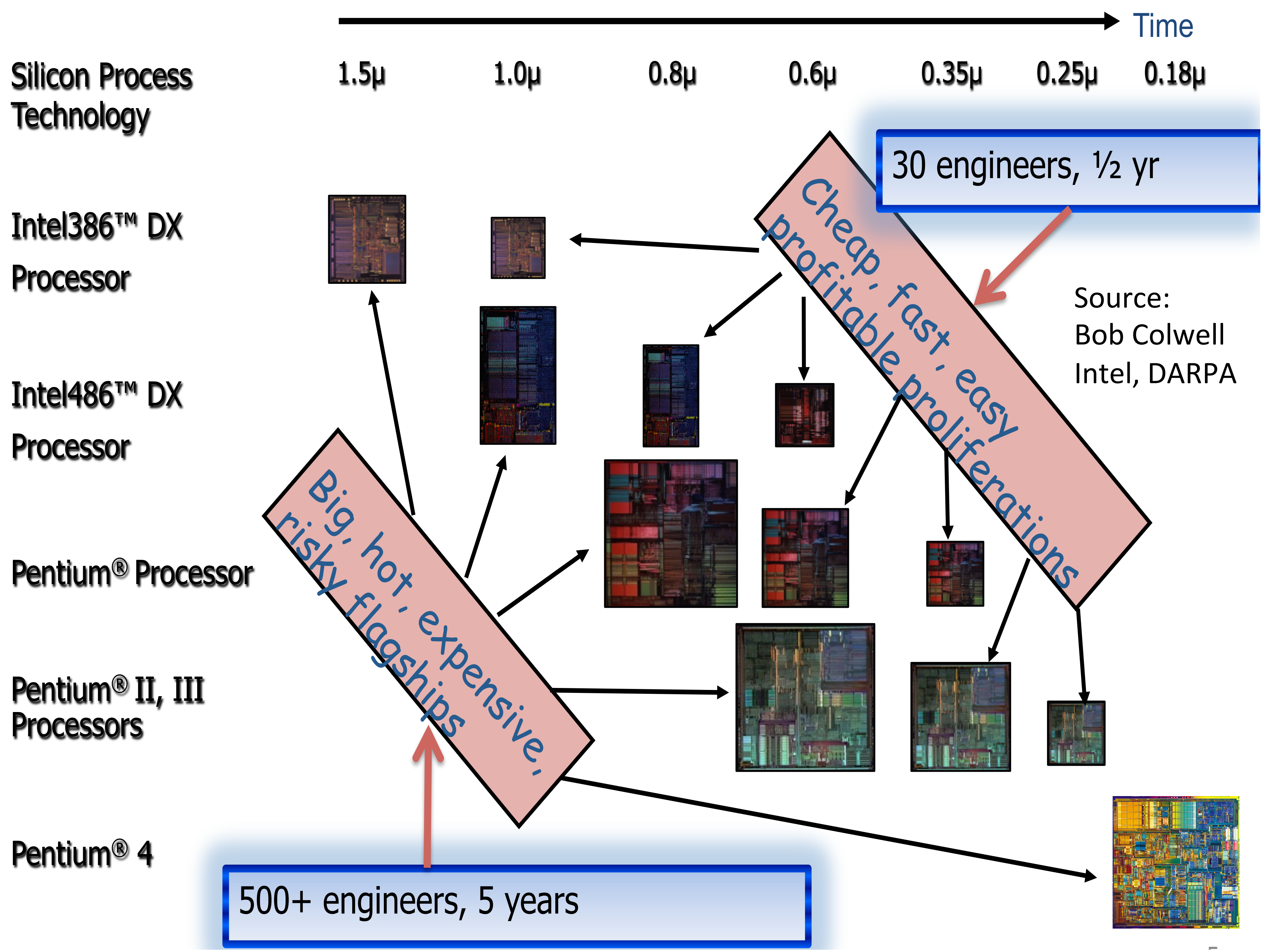
Special Session Presentation

EXTREME SCALE DESIGN AUTOMATION

CCC/SIGDA Workshop Series

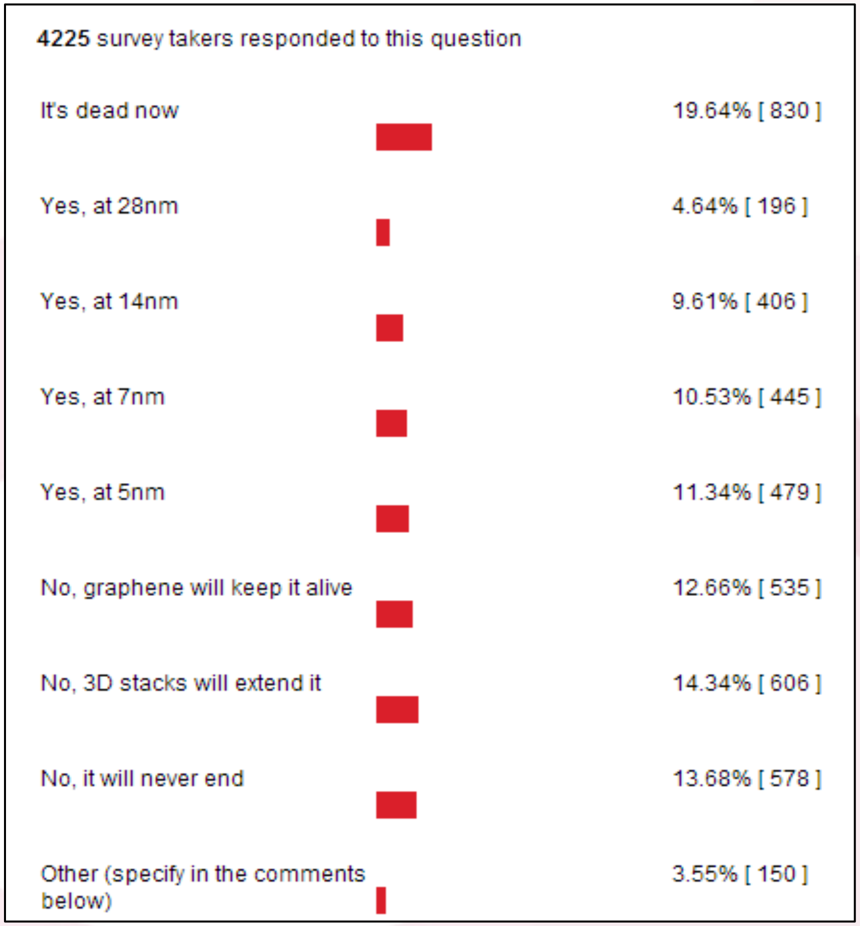
Alex K. Jones

University of Pittsburgh



Time
Silicon Process Technology
1.5μ
1.0μ
0.8μ
0.6μ
0.35μ
0.25μ
0.18μ
Intel386™ DX Processor
Intel486™ DX Processor
Pentium® Processor
Pentium® II, III Processors
Pentium® 4
30 engineers, ½ yr
Cheap, fast, easy profitable proliferations
Source: Bob Colwell Intel, DARPA
Big, hot, expensive, risky flagships
500+ engineers, 5 years

SURVEY: WILL MOORE'S LAW END?



- Traditional (Dennard) scaling ended 10 years ago (sub 80nm)
- Industry roadmap will continue to find patches to silicon (5nm)
  - *Seems the cost scaling proposition may have ended*

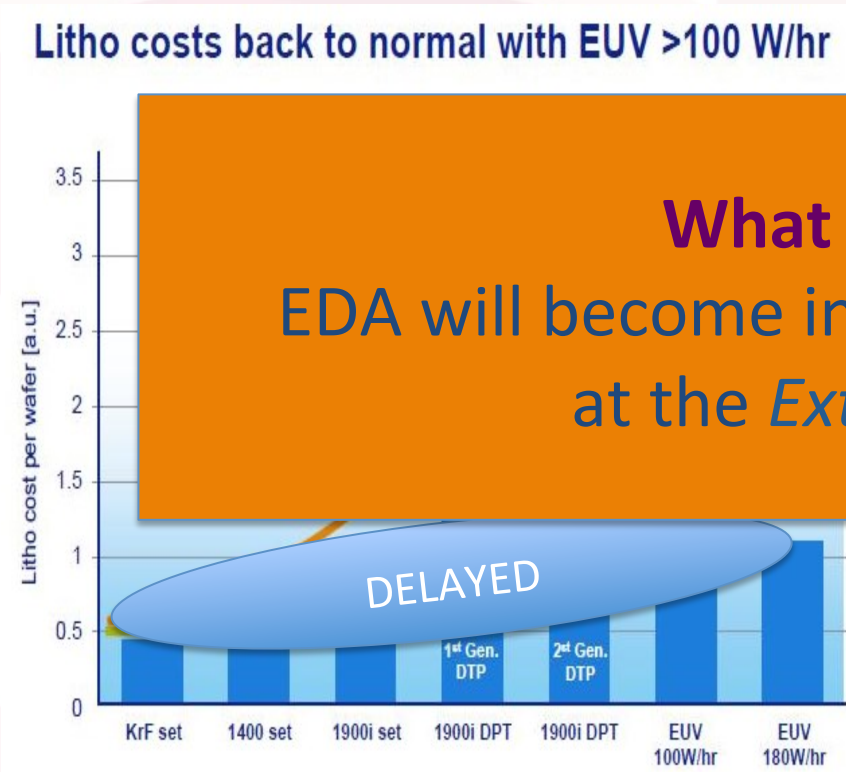
EDA is still chasing a *multi-dimensional* moving target

Source: EE Times Survey
March 2014

EXTREME SCALE SILICON ROADMAP

EUV Saves Costs versus Double Patterning

450mm Increases Throughput to Save Cost



What is clear?

EDA will become increasingly important at the *Extreme Scale*

FD-SOI?

All around gate transistors?

Will scale to 10nm? 7nm? 5nm?

CCC/SIGDA WORKSHOPS ON EXTREME SCALE DESIGN AUTOMATION

Series of three workshops:

- Workshop 1: **Emerging Technologies and Workforce Continuity**
  - March 7-8, 2013 Pittsburgh
- Works… **…arch**
  - Ju…

The purpose of this workshop series was to take an introspective look at the EDA field while crystalizing a vision for both the near and long term.

- Workshop 3: **Achieving Sustainable Collaborations Through Abstractions, Methodologies, and Benchmarks**
  - February 20-21, 2014 Tampa

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WHERE SHOULD EDA INVEST?

Major Focus Areas

- **Extreme-scale Electronic Design Automation (ESDA)**
  - First *Big Data* Discipline, 10^{15} devices
  - Focus on *System-level Design* and *Verification*
- **Emerging Technologies (Post-CMOS/Hybrid)**
  - Develop Full System Flows
  - Technology choices: more than *ad hoc* demonstrations
- **New Markets (DAoT)**
  - Near term: CPS/IoT, Cyber-secure systems (hardware)
  - Medium term: Biology/Medical Technology

- **Cross Cutting**
  - Abstractions, Metrics, Benchmarks
  - Synergy with Computer Architecture
  - Education and Workforce

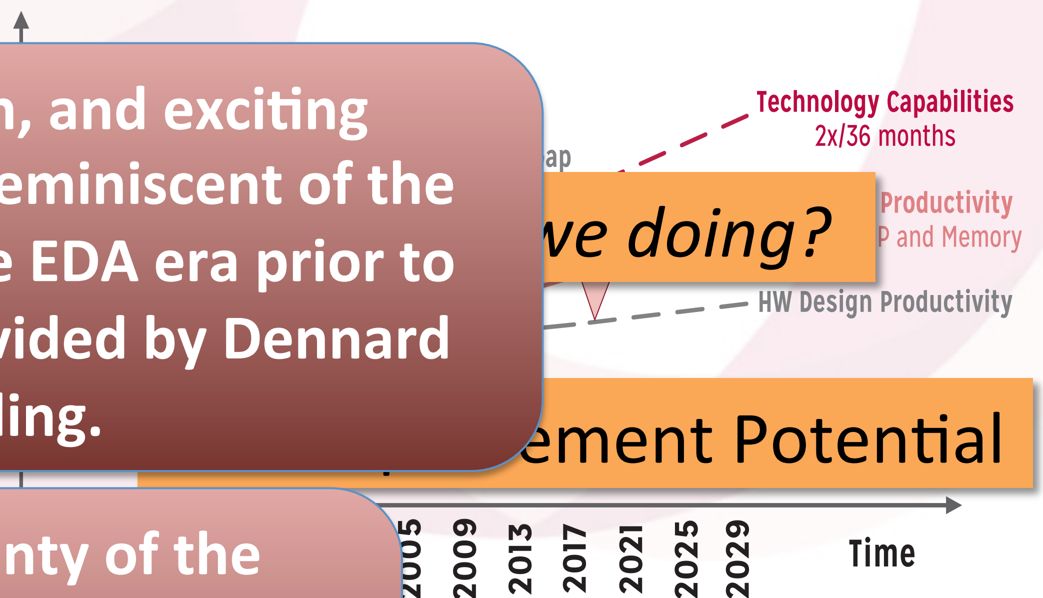
EXTREME SCALE DESIGN AUTOMATION

Continuing Onward: Next-Generation Electronic Systems

ESDA IS AN EXCITING TIME FOR EDA

EDA's Objectives "at a glance"

ITRS Productivity Curve



This uncertain, and exciting environment is reminiscent of the beginnings of the EDA era prior to the stability provided by Dennard scaling.

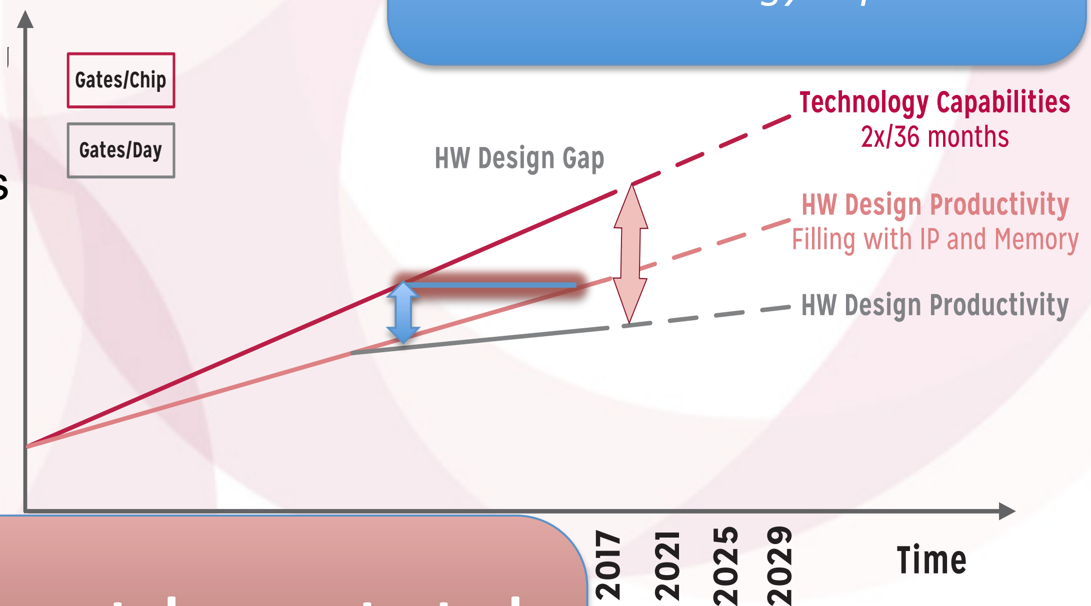
Uncertainty of the current environment is alleviated by the large global demand for IC products

WHAT ABOUT "LEGACY" TECHNOLOGY NODES?

130nm design starts dominate th

Closing the productivity gap at 130nm could approximate current technology capabilities

- Barriers
  - "Good enough solutions"
  - Fear new methods break tools
    - Unintended side effects
- Push button flows still achievable
  - Inadequate investment



- *130nm des*
  - Reduc
  - Increa

An EDA advancement demonstrated in a tool that finds superior solutions is particularly valuable to effectively utilize legacy technology nodes.

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HYBRID POST-CMOS ELECTRONICS

A Changing Landscape: New Technologies for Integrated Circuits

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ROLE OF EMERGING TECHNOLOGIES

Replace Si-CMOS?

- There are many emerging technologie
  - Most ar
  - Likely h
- Challenges
  - Integrat
  - Stochast
  - Models and abstractions
  - Full system demonstrations

TECHNOLOGY	PROPOSED USE
Optical interconnect, optical devices	High-performance, high-bandwidth communications
Terahertz (RF) circuits	Automotive radar, security, high-bandwidth wireless ...cation
	... filter/switches, wideband antennas, ...s, energy harvesting, data storage,
	...ynapse, physical brain/biomimetric
	...omputing, body tracking, glucose
	...computing/annealing/optimization
Phase-change memories (including memristors)	DNA memory (having long retention)
Microfludicis	Lab-on-a-chip, cooling
Steep slope devices	Ultra low-power computing
Superconductors	Ultra low-power computing, ultra high performance
Carbon-based electronics	Ultra low-power computing, high performance, monolithic 3D ICs

EDA should not *determine* which new technologies to pursue.
EDA should address new technology specific challenges for EDA flows.

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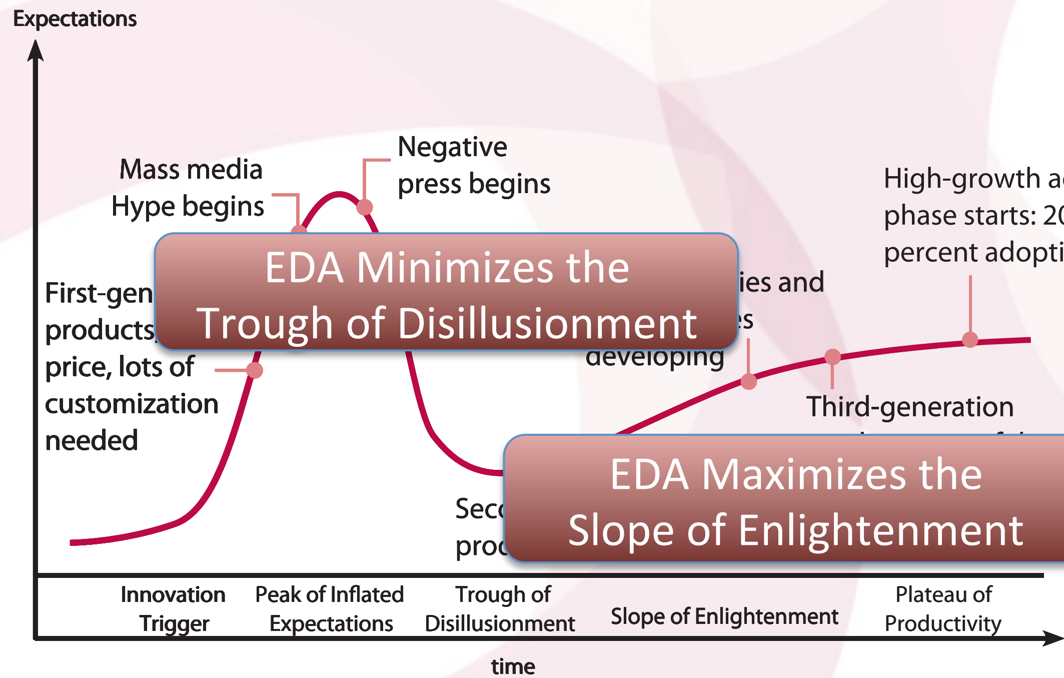
THE HYPE CYCLE OF INNOVATION

Generalized Pattern of Research and Commercialization
From Conception to Productive Use



Source: Gartner

EDA Minimizes the Trough of Disillusionment

EDA Maximizes the Slope of Enlightenment

EDA Can Lead to Concrete Evaluation of New Technologies

NSF NEB Program–EDA should be included

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THE DESIGN AUTOMATION OF THINGS

Looking Forward: New Markets and Applications

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THE POWER OF DESIGN AUTOMATION

Biological and Medical Technologies

Si/
CMOS

- EDA separates
  - Design
  - Construction
  - Optimization
- Clear abstraction & predictive models of low-level behavior allows:
  - High level analysis
  - Optimization
  - Verification

Cyber-physical Systems

DA Techniques Beneficial to Areas

- Require analysis before construction
- Lack appropriate abstractions
- both optimization and to meet specs
- ke low cost alternatives to high cost products
- Need efficient assessment of ou

Cyber-secure Systems

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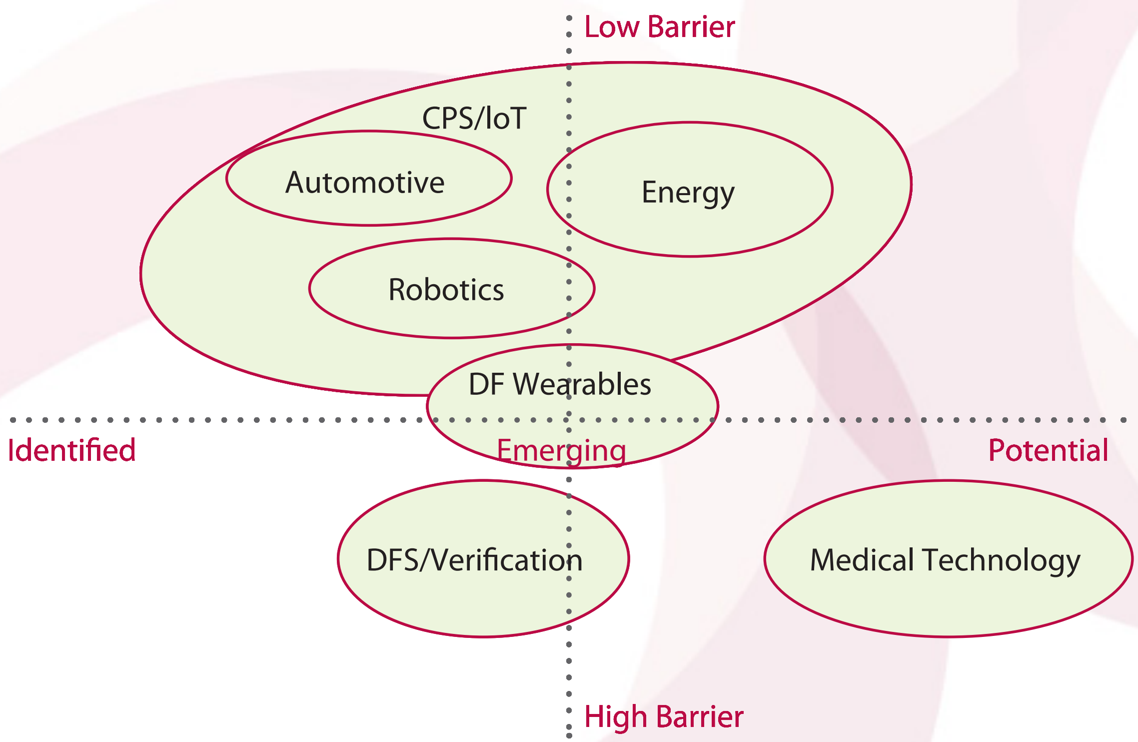
NEW MARKETS WHERE DESIGN AUTOMATION CAN BE TRANSFERRED



NSF CPS– EDA identified but missing

NSF STARSS– EDA also missing

NSF EFRI– BioDA potential topic

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CROSS CUTTING CHALLENGES

Abstractions, Metrics, and Benchmarks

Education and Workforce

Synergies with Computer Architecture

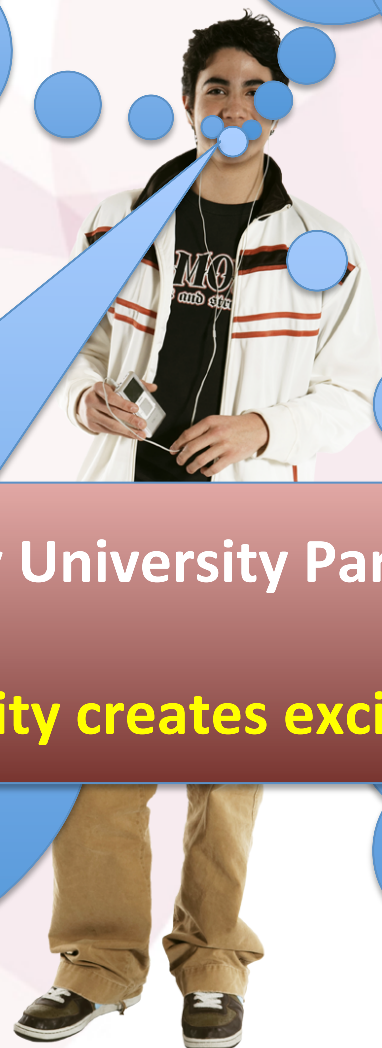
EDUCATING IN EDA

“EDA? But I want to do something *cool*!”

“EDA? But I want to save the planet!”

- Students want to impact society
- EDA is not perceived to “change the world”

- EDA is TWO levels of indirection away from “cool”



“What do y
the tools
chips tha
smartphone
write apps for Google?”

oo
o
nd
algorithms and
stuff!”

Industry University Partnerships!

Activity creates excitement

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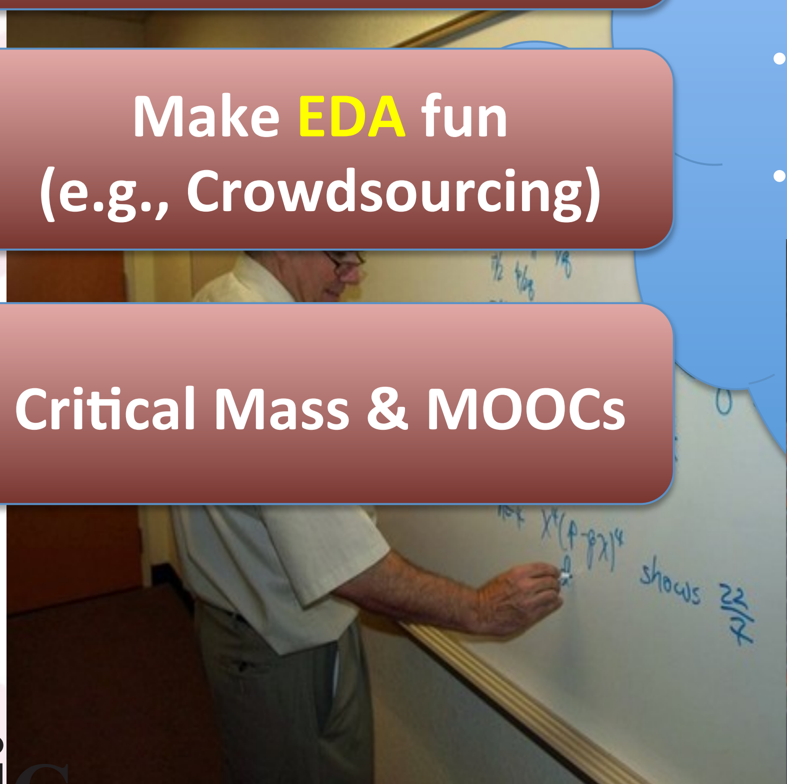
CURRICULUM AND STRATEGY

Better marketing to students

Make EDA fun (e.g., Crowdsourcing)

Critical Mass & MOOCs



- basics
- Students w... the importan... f ... ourse
- We sho... call th... urse what i... "formal ... hods

CONCLUSIONS

DIMENSIONS OF FUTURE EDA ACTIVITIES

	Electronics: Hybrid CMOS with Emerging Technologies		New Markets: Cyber-physical, Cyber-secure, and Bio-medical Technologies
Traditional EDA Tool-kit	Immediate Need: EDA for scaled CMOS + product ready tech		Immediate Need: EDA applied to near fields – automotive, robotics, and energy
EDA Approaches on Big Data	Transformative: Big data research–system level design and verification		Transformative: EDA big-data methodologies applied to far fields – synthetic bio, systems bio, medical devices

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FINAL REPORT AVAILABLE

Workshops on Extreme Scale Design Automation (ESDA) Challenges and Opportunities for 2025 and Beyond

R. Iris Bahar, Alex K. Jones, Srinivas Katkoori, Patrick H. Madden, Diana Marculescu, and Igor L. Markov

Abstract

Integrated circuits and electronic systems, as well as design technologies, are evolving at a great rate—both quantitatively and qualitatively. Major developments include new interconnects and switching devices with atomic-scale uncertainty, the depth and scale of on-chip integration, electronic system-level integration, the increasing significance of software, as well as more effective means of design entry, compilation, algorithmic optimization, numerical simulation, pre- and post-silicon design validation, and chip test. Application targets and key markets are also shifting substantially from desktop CPUs to mobile platforms to an *Internet-of-Things* infrastructure. In light of these changes in electronic design contexts and given EDA's significant dependence on such context, the EDA community must adapt to these changes and focus on the opportunities for research and commercial success. The CCC workshop series on Extreme-Scale Design Automation, organized with the support of ACM SIGDA, studied challenges faced by the EDA community as well as new and exciting opportunities currently available. This document represents a summary of the findings from these meetings.

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For more information
http://www.cra.org/ccc/visioning/visioning-activities/esda

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