Software for Dependable Systems: Research Needs and NSF Perspectives

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Software for Dependable Systems: Sufficient Evidence? Symposium
National Academy of Sciences
October 23, 2007

U.S Broader Research Agenda and Priorities

President's Council of Advisors on Science and Technology

Networking and Information Technology Research and Development

- PCAST/NITRD report [August 2007]
  - Dan Reed and George Scalise
  - 8 priority areas listed, with the recommendation that the first 4 get disproportionately larger funding increases.

- #1 Priority: Cyber-Physical Systems
  - Our lives depend on them.
- #2 Priority: Software
  - Software is everywhere and in everything.
- #6 Priority: CyberTrust
  - In particular, foundations, e.g., models and logics for reasoning.

NSF Relevant Programs: New FY08

- Software for Real-World Systems (CISE-wide)
  - Goal: Bring foundations of software researchers and systems researchers together. Working with industry encouraged.
  - $10M, 12-20 awards, proposals due Jan. 17, 2008

- Cyber-Enabled Discovery and Innovation (NSF-wide)
  - Goal: Computational Thinking for science and engineering
  - Three dimensions
    - From Data to Knowledge
    - Understanding Complexity in Natural, Built, and Social Systems
    - Virtual Organizations
  - $52M, with $20M from CISE, FY08 is first of five years

CISE Relevant Ongoing Core Programs

- Computing Processes and Artifacts (in CCF Division)
  - Includes formal methods, programming languages, static and dynamic analysis, software engineering
- Computer Systems Research (in CNS Division)
  - Includes cyber-physical systems
- Cybertrust (in CNS Division)
  - Includes security, reliability, privacy, usability
- Information and Intelligent Systems (IIS) Division
  - Includes foci on human, team, and social roles in systems development

The Harder Question

Computer scientists have been researching [formal methods] for at least four decades. What could make a real difference to the speed at which [formal methods] permeate industrial and commercial software development?

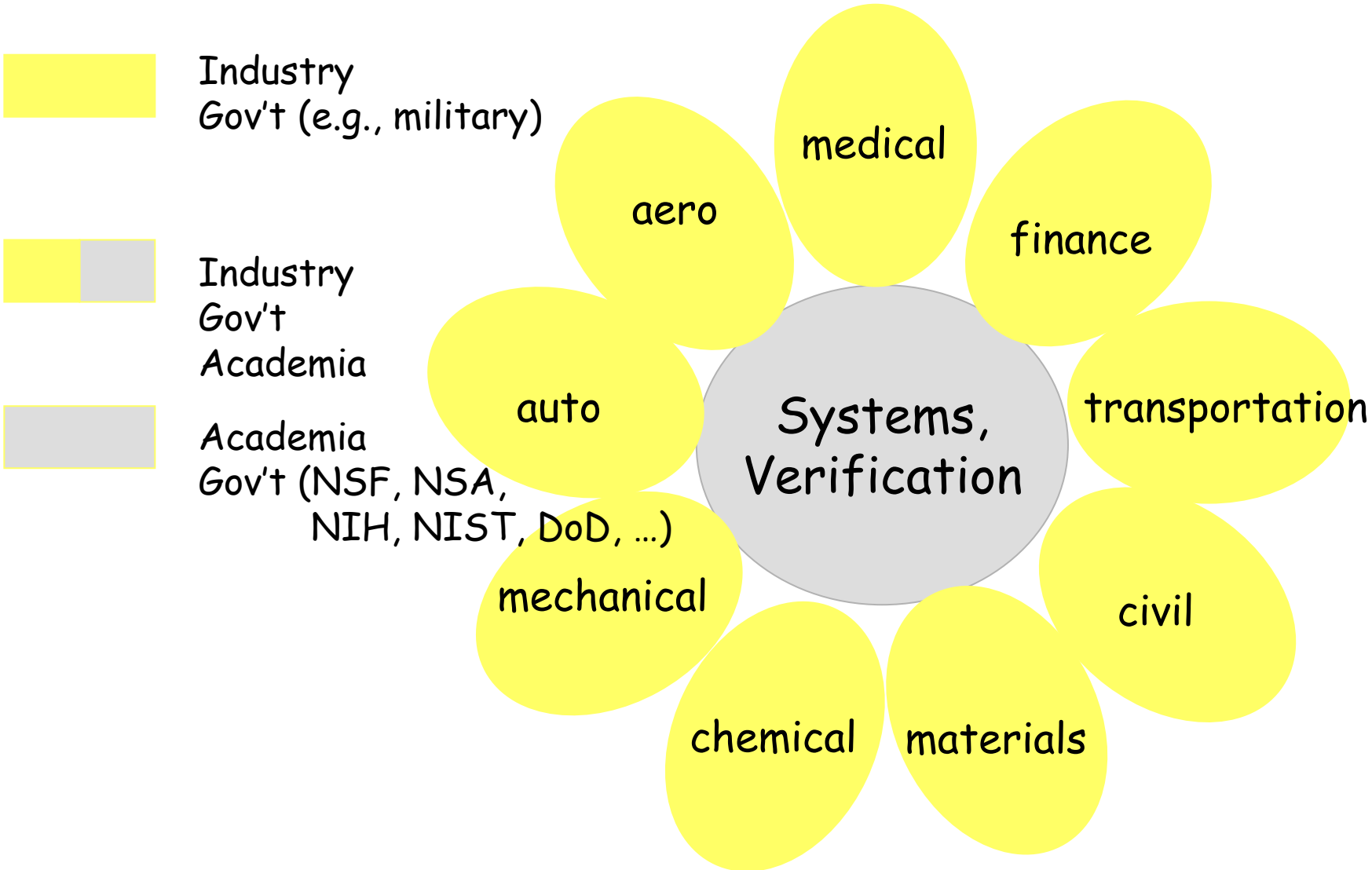
High-Level Answers

- Lightweight formal methods [Jackson and Wing 1996]
  - Laser beam vs. light bulb approach
    - Focus on one critical property (at a time)
    - Focus on one critical component (at a time)

- Training and education
  - Teach formal methods to undergrads. Engage them in your research.

- Academics-Industry-Government Partnerships
  - Academics have to work with domain experts from industry or a gov't lab
  - Industry and/or gov't lab have to be willing to work with academics.
  - Successful collaborations start at the grassroots
    - Embed academics in industry/gov't lab and v.v.
    - SLAM story. Two Ph.D.s in formal methods hired in the development org.
  - Also need buy in from the top
  - Models of collaboration/consortia
    - Many consortia have failed. We should understand why.
    - Semiconductor Research Corporation model—successful for hardware!
    - Flower model (see next slide)

A Model for Expediting Progress



Scientific Research Challenges

- We need new advances in software foundations.
  - What does "correctness" mean?
    - Factor in context of use, unpredictable environment, emergent properties, dynamism
  - What are the desired properties of and metrics for both software (e.g., weak compositionality) and systems (e.g., power)?
  - What is a complexity theory for real-world systems as we have a complexity theory for algorithms?

- We need new advances in formal models and logics
  - For complex systems, e.g., hybrid systems
  - For a richer set of properties, e.g., privacy, cost, power
  - For multiple purposes, e.g., verification, simulation, prediction

Engineering Research Challenges

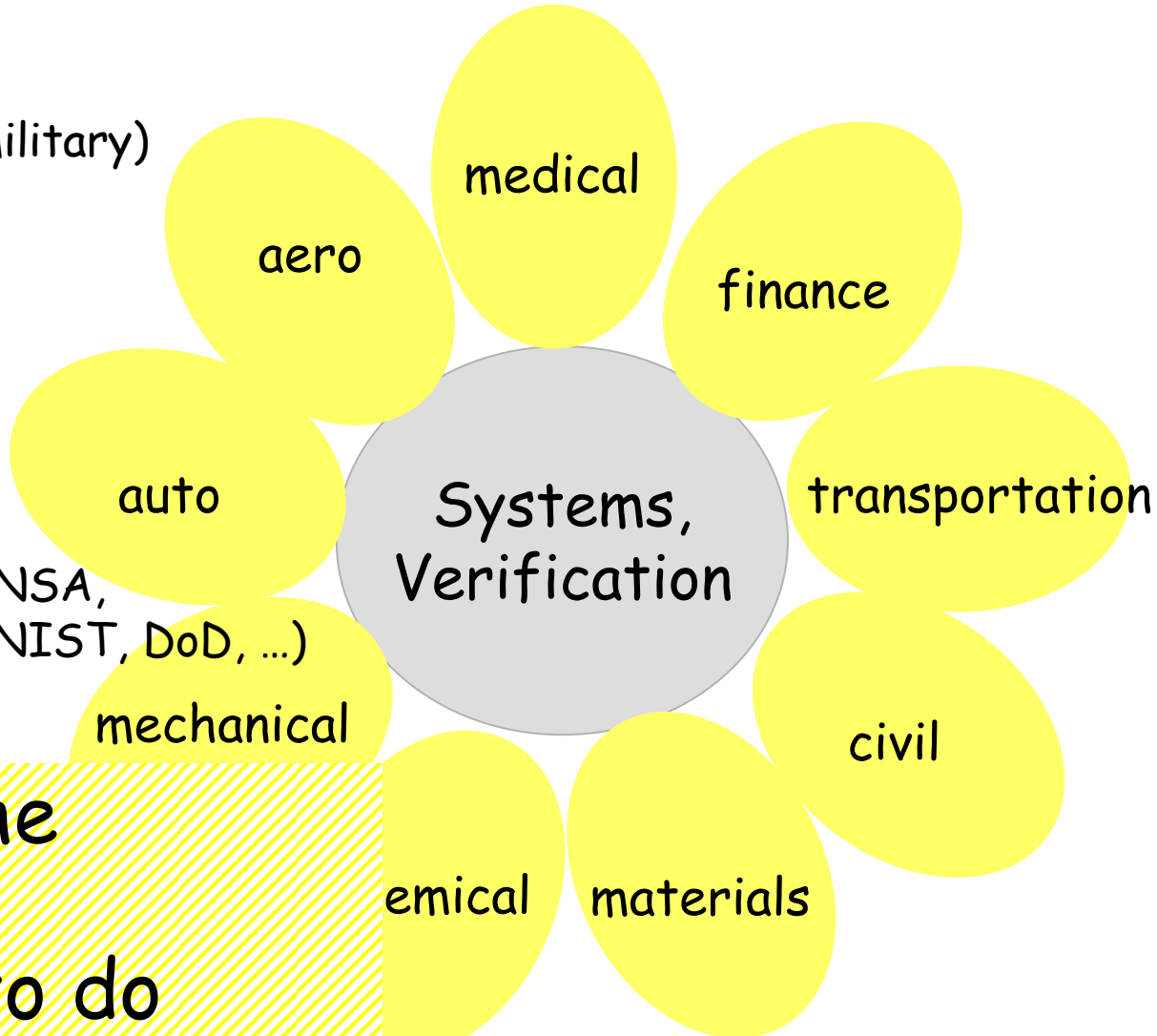
- We need new advances in verification tools for systems builders and domain engineers
  - Push-button
  - Usable
  - Integrated with rest of system development process
- We need new engineering processes for creating software-intensive systems.
  - Traditional ones won't work.

A Model for Expediting Progress

Industry
Gov't (e.g., military)

Industry
Gov't
Academia

Academia
Gov't (NSF, NSA,
NIH, NIST, DoD, …)



Do we have the courage and commitment to do something like this?

Thank you!