Carnegie Mellon
School of Computer Science

isr institute for SOFTWARE RESEARCH

Carnegie Mellon and SERC

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Carnegie Mellon and the SERC

- Status
  - Expect to be onboard later this Fall
- Background
  - Systems and software engineering at CMU
  - The CMU Institute for Software Research in the School of Computer Science
    - Technical specialties
- Areas for potential engagement
  - Potential technical areas of focus

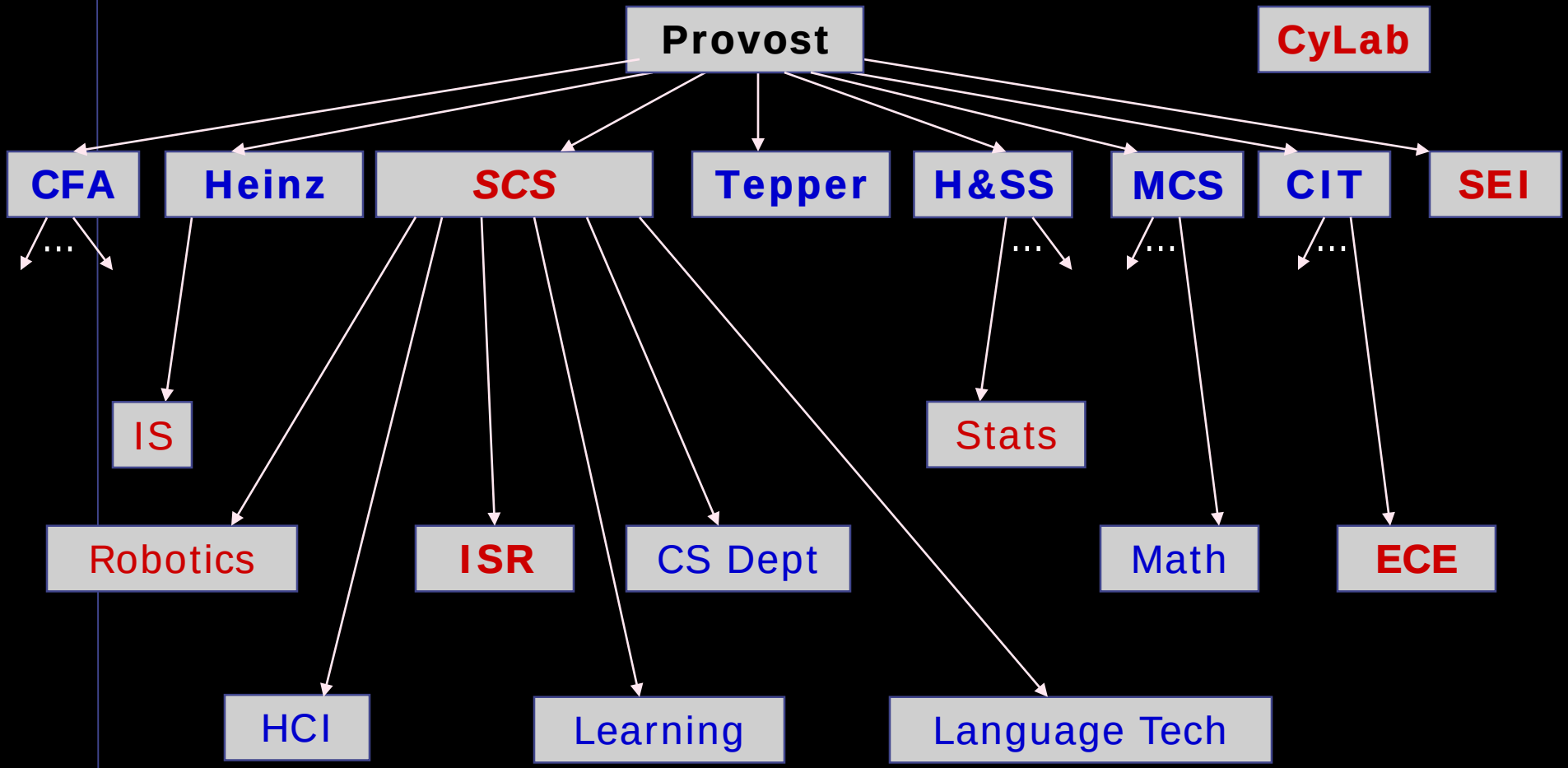
Carnegie Mellon

SE and software at Carnegie Mellon

institute for SOFTWARE RESEARCH

- Computer science and systems research and education
  - School of Computer Science (SCS)
  - Electrical and Computer Engineering (ECE)
- Public policy, e-business, IT
  - Sloan Software Industry Center (ISR)
  - Heinz School of Public Policy and Management
  - Tepper School of Business
- Software engineering and transition
  - Software Engineering Institute (SEI)
- Cybersecurity
  - CERT at the SEI
  - CyLab
  - CIT, CERT, Heinz, SCS
- Extended campuses and International collaboration
  - Qatar
  - Silicon Valley
  - Korea
  - Portugal
  - India
  - Australia
  - Japan

SE and software at Carnegie Mellon



CMU – What's Special?

- Success in interdisciplinary research
  - HCI, Robotics, Software engineering
- Engagement with challenges from industry and government
  - NASA, DoD, NSF, NIH, etc.
  - Public policy and technology
- Engineering attitude – we build things
  - Andrew, Mach, Darpa Challenge
- Innovation at the boundaries
  - NLP, model checking, software analysis, ICTD
- Strategic risk taking
  - Computing, Robotics, HCII, CyLab
- Entrepreneurial institutional attitude

SCS – What's Special?

- Quality
  - #1 ranking (along with MIT, Stanford, Berkeley)
  - Unusual strengths
- CMU attitude
  - Innovation, engagement, success at boundaries
- Few barriers
  - Faculty are citizens of SCS
  - PhD students can be advised/supported nearly anywhere in SCS
    - Joint cross-unit advising
- Diversity
  - Many research styles with safe homes
  - Diverse linkages with related and application disciplines

ISR – What's Special?

- Scientific advances to solve practical problems
  - *Software engineering* (SE)
    - *Application of CS to the engineering of software*
    - Analysis, architecture, measurement, teams, embedded, security
  - *Computer Organizations and Society* (COS)
    - *Information and computing problems in society*
    - Social network analysis, security, mobility and devices, privacy
- Long horizon
  - Motivated by practical problems of government and industry
  - Scientific results with broad long-term significance
- Educational commitment
  - PhD in SE, COS. Professional MS programs. Undergraduate.
- Organization
  - Approx 25 faculty, 75 technical + admin staff, 200 PhD + MS students
  - Budget is evenly split research and education

ISR and Research

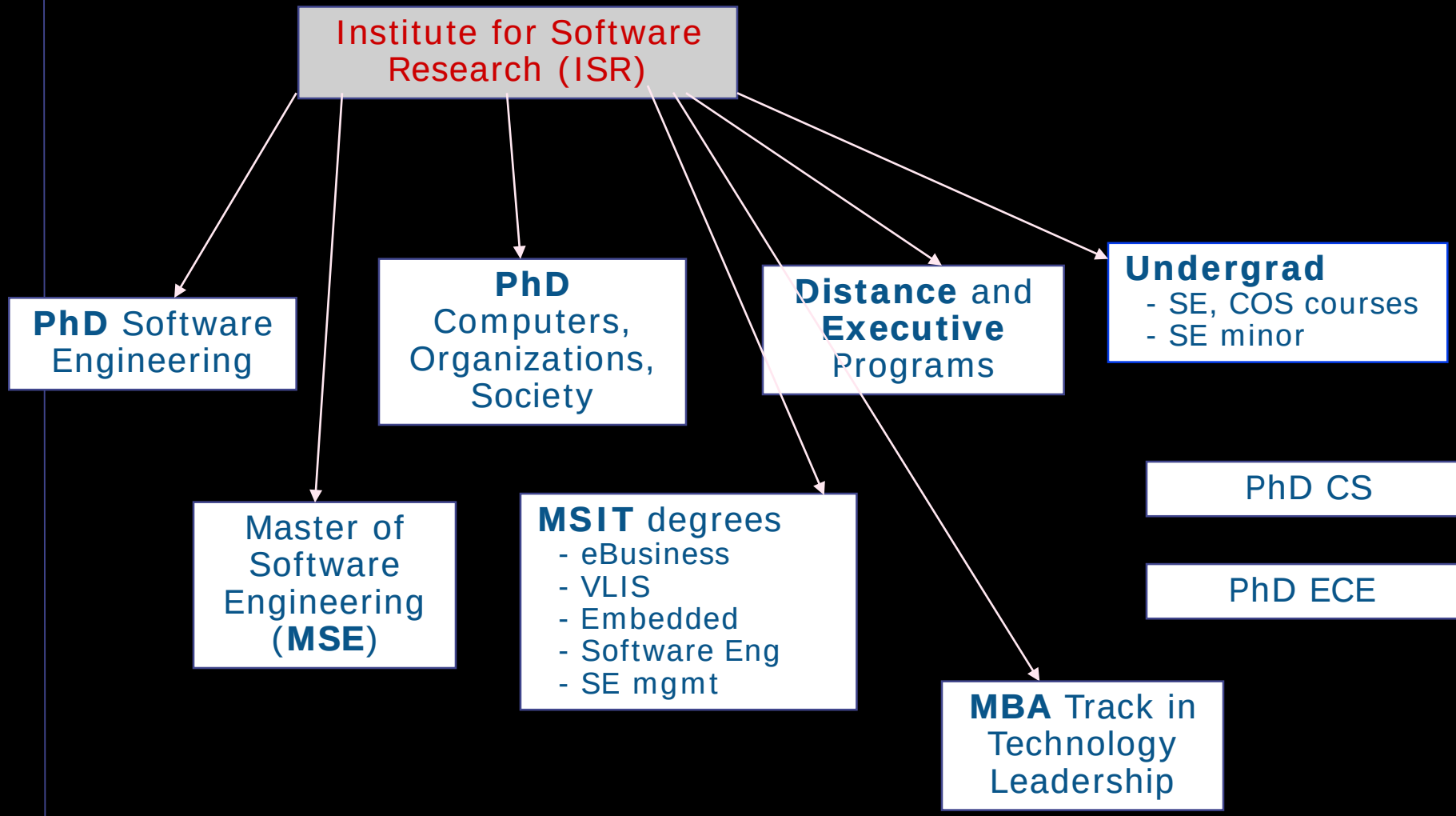
Software Engineering Research

- Software analysis and measurement
  - Assurance and high confidence
- Architecture specification, analysis
  - Frameworks, libraries, patterns
  - Robustness
- Teams and coordination
  - Open source, outsourcing, architecture
- Embedded and real-time
  - Critical systems
- Cybersecurity
- Collaboration with industry, government
- Technology and policy involvement

COS Research

- Social network analysis
  - Querying and mining of graph-based models
- Privacy
  - Policy specification
  - Ambiguity and identity inference
- Supply chain operations
  - Agent models for supply chain management
- Mobility and location
  - Interoperation, privacy, security

ISR and Education



ISR and Education – MS, BS programs

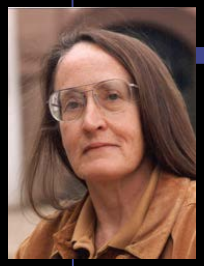
- MSE in 20th year (Garlan, Rosso, Lattanze)
  - Local and distance offerings
    - International programs in Korea, Portugal, India
    - Distance programs with industry
      - Evolved best practices: faculty training, ..
  - Practicum and studio projects with external clients
    - Google, L3, Bosch, SEI, GM, Ford, Siemens, Intel, …
  - Strong alumni community (more than 230 grads)
  - MSIT-SE programs with India, South Africa (more than 140 grads)
- MSIT E-Business (Shamos)
  - Learning-by-doing mentor-based instruction
  - Practicum and studio projects with external clients
- MSIT Very Large Information Systems (Tomasic)
  - Massive data repositories: analysis, access, storage, quality
  - Links with LTI, MLD, others
- Software Engineering undergraduate minor
  - Innovative undergraduate course offerings
- Executive programs, primarily in software engineering

ISR and Education – PhD Faculty

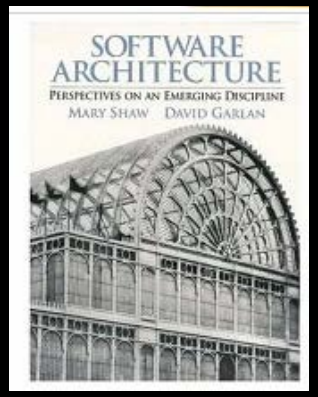
- Software Engineering
  - Core Faculty
    - William Scherlis
    - David Garlan
    - Mary Shaw
    - Jim Herbsleb
    - Jonathan Aldrich
  - Affiliate Faculty
    - Len Bass (SEI)
    - Brad Meyers (HCII)
    - Mark Paulk
    - Mike Reiter (ECE → UNC)
    - Dan Siewiorek (HCII)
    - Priya Narasimhan (ECE)
- Computation, Organizations, and Society
  - Core Faculty
    - Kathleen M. Carley
    - Norman Sadeh
    - Latanya Sweeney
    - Lorrie Cranor
    - Raj Reddy
    - Dave Farber
    - Rahul Tongia
    - Michael Shamos
    - Jim Herbsleb
  - Affiliate Faculty
    - Tuomas Sandholm
    - Bill Hefley
    - Jane Siegel
    - Dave Krackhardt
    - Jaime Carbonell

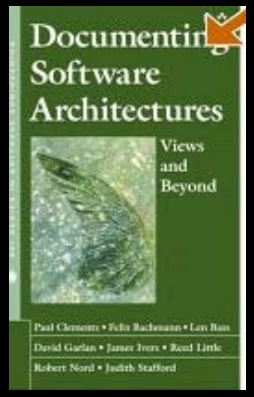
ISR Impact – Software Engineering

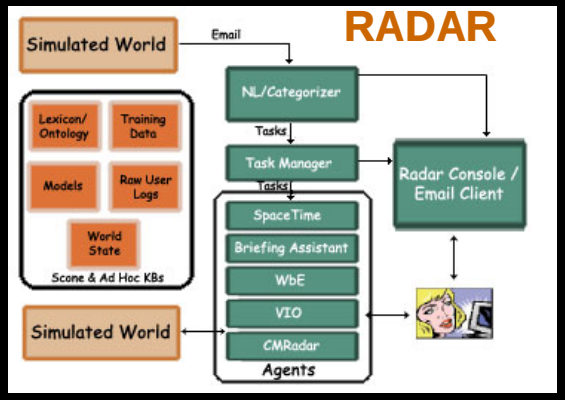
- Software Architecture (Garlan, Shaw)
  - Defined the discipline
    - Shaw and Garlan, 1996 – *Software Architecture: Perspectives on an Emerging Discipline*
    - Stevens Award (Garlan)
    - JOLT Productivity Award – *Documenting Software Architecture: Views and Beyond* (Garlan)
  - Next steps
    - Self-healing and self-managing systems
    - Task-oriented computing (Aura, RADAR)
    - Abstractions for end-user programming



software development 16th annual product excellence award JOLT



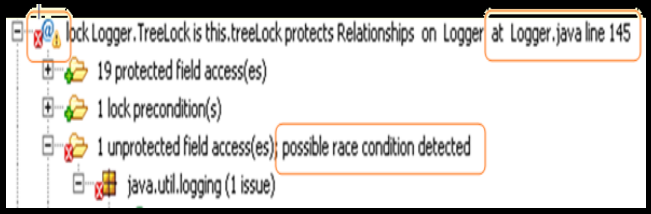




ISR Impact – Software Engineering

- Software Analysis (Aldrich, Scherlis)
  - Themes – scale, composition, realism
    - Scale to existing large systems
    - Adoptable in development practice
    - Focused design intent → *analysis based verification*
      - *small theorems about big programs*

  - Analysis capabilities (*examples*)
    - Concurrency: shared and distributed
      - Race conditions and thread policy
    - Framework and API compliance (Aldrich CAREER, Dahl-Nygaard)
    - Typestates
    - Architecture compliance
    - Refactoring support

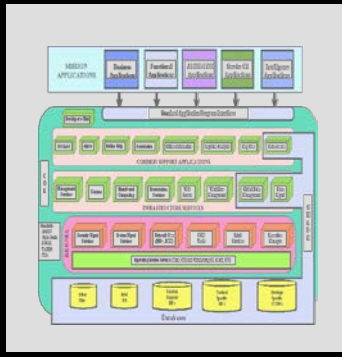


  - Impact
    - Spinoff of Fluid technology to **SureLogic**

Assurance: Two areas of focus

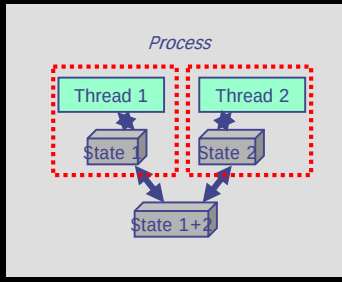
The system interior

- The system security perimeter is now the interior
  - Diverse component sources → diverse levels of trust
  - Indicators: Reliance on provenance and insider trust
- Analysis must focus at composition points and APIs
  - Information flows. Protocol compliance.



Concurrent and distributed systems

- Intermittent corruption and deadlock
  - Defies conventional testing and inspection
  - Current focus: Outsource or “play the odds”
- Analysis must effectively address concurrency
  - Scale motivates complex memory models
- Distributed and shared memory systems
  - Observability challenges

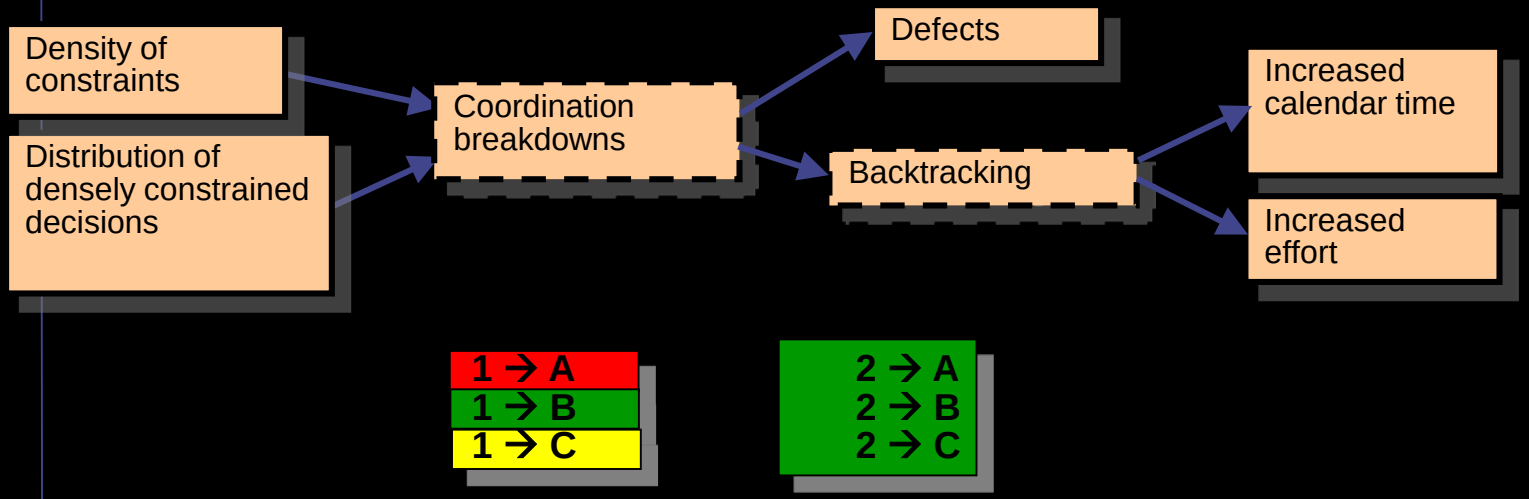


Areas of focus in this report

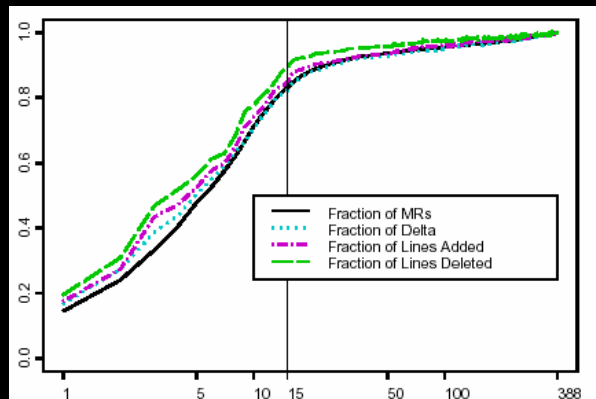
1. Cloud monitoring
   - Tighter iteration from development to operations and back
   - Dynamic analysis ←→ targeted monitoring
     - High performance dynamic analysis and monitoring for existing complex applications
     - Focus on access and protection of critical state
2. Safe concurrency
   - Assurance of safety and security for concurrent software
   - Difficult for testing, inspection, heuristic methods
   - Sound static and dynamic methods
     - Sound analysis based on abstract interpretation
     - Dynamic analysis, monitoring
3. Diverse components
   - Apps are more aggregated and more diversely sourced
   - Increased focus on APIs, framework interfaces, “interoperation”
     - Static analysis for compliance with API rules
     - Information flows and encapsulation, resource usage, etc.
4. Bug forensics
   - Team servers capture rich data for secure software devt
     - Complex hybrid queries of code, architecture, and developer roles

ISR Impact – SE / COS

- Conway's Law (Herbsleb)
  - Relating project structure and organizational structure
    - How to modularize projects and tasks
  - Best developers (rapid resolution) coordinate better



- Open Source Ecologies (Herbsleb)
  - Productivity
  - Quality
  - Coordination, etc.



ISR Impact – COS

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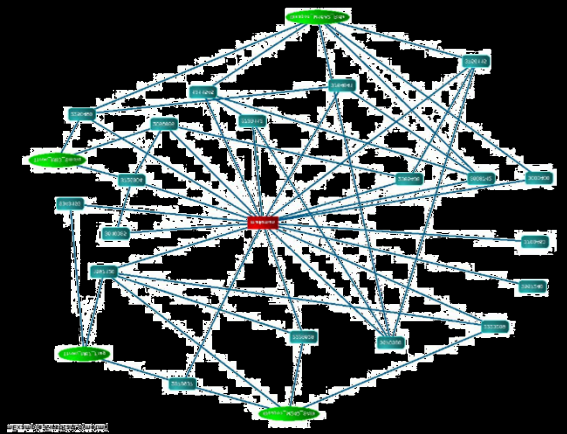
- Social Networks (Carley)
  - Featured in IEEE Spectrum
  - Featured in NY Times Magazine “Year in Ideas”
  - 3 best paper awards
  - Applied graph theory, data mining
  - Diverse applications
    - Law enforcement
    - Terrorism, intelligence
    - Engineering teams



Carnegie Mellon DATA PRIVACY LAB

- Data Privacy (Sweeney)
  - Identity Angel (alert when private info appears on web)
  - Created k-anonymity
  - Influenced federal health information privacy rules

Example areas for engagement

- Technology and practices
  - Software assurance practices, tools, and field trials
    - Scale (composition) and adoptability (usability, incrementality)
  - Improved measurement techniques and tools to support teams, process, etc
  - Supply-chain issues (team, architecture, Conway's Law)
    - Sourcing, communication
  - Architecture and process
    - Dynamism, scale, compliance
  - Software and associated systems challenges related to modern platforms
    - Multicore and distributed concurrent
    - Large-scale data-intensive
    - Cloud infrastructure and systems
  - Human systems integration – architectural perspective
- Educational innovation
  - Professional and executive curriculum
    - MSE now in its 20th year
    - Many additional professional MS degrees
  - Innovative undergraduate software engineering curriculum
    - Didactic and project courses

Thrust and focus areas

- Enterprise responsiveness
  - Collaboration
  - Modeling
  - Resilient system
  - Producibility
  - Parsimony
  - Strategic assessment
- Basic systems science
  - Composition
  - System conceptualization
  - Validation
  - Transformation
- Human capital
  - Collaboration and education
  - Acceleration
  - Dispersion
- Program management
  - Assessment
  - Teambuilding
  - SoS, enterprises
  - Services
- Life cycle processes
  - Life cycle models
  - Balance
  - Architecting