Software-Intensive Systems
Producibility Research

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Presentation Overview

• Agenda
  – DoD’s needs for producing Software-Intensive Systems
    • F-22, SBIRS High
    • Future Developments
  – Current efforts to address Software-Intensive Systems (SIS) Producibility
  – Envisioned program
DoD’s SIS Challenge

“DoD estimates that it spends about 40% of its RDT&E budget on software - $21B for FY2003” – GAO

“[Software] continues to grow in importance in our weapons systems - and remains a significant contributor to program cost, schedule and performance shortfalls.” -- Pete Aldridge
Opportunities for Improvement

• Development tools do not adequately provide system-level awareness
  – Start-up, shut-down, reconfiguration
  – Establish, track, assess system-level properties
    • Reliability, Resource utilization, Deadlines etc.
  – Enforcement of design principles during development
• Development details still dominated by expert involvement and peer reviews
Capability Provided by Software in DoD Systems is Increasing but so are the Challenges...

Ref: Defense Systems Management College
DoD Software is Growing in Size and Complexity

总装机计算机容量 (OFP)

Opportunities for Improvement

- Software and System development tool suites must:
  - Automate tasks not done consistently well by humans
    - Code generation
    - Enforcement of architectural policies
  - Provide consolidated system-awareness
    - Service, resource and application prioritization
    - Design trade-offs
  - Simplify testing and verification
Army Future Combat System
Challenges

“The software task alone is five times larger than that required for Joint Strike Fighter and ten times larger than the F-22, which after two decades is finally meeting its software requirements.”

- Congressman Curt Weldon, House Armed Services Committee tactical air and land forces subcommittee hearing April 1, 2004 as quoted in Defense News April 12, 2004

• Emphasis on network dependence
• V&V will be difficult
Opportunities for Improvement

• Development environments for net-reliant embedded systems must:
  – Readily embrace emerging data and knowledge management strategies
  – Automatically facilitate and assess interoperability protocol implementation compatibility
  – Address system-of-systems design
    • Properties-in-the-large, composeability, security
  – Accommodate data and functional uncertainties associated with ad-hoc networks and transient application relationships

• System-of-Systems Verification
Emerging Interests

• Software Assurance
  – Ensuring applications and infrastructure are free from vulnerabilities and malware

• Open Technology Development
  – Open Source
  – Open Standards
Overview – Existing Program

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Workshops

• #1 Establish Overall Research Agenda
  – Held May 17/18 2005 - ZAI, Rosslyn VA

• #2 Establish Research Goals, Infrastructure Requirements
  – Held July 2005 – UC Berkeley

• #3 Industry – Transition & Motivation
  – Scheduled for May 17-19 2006
    • ZAI Rosslyn VA
  – Include Gov/Industry Exec Session May 19
National Academies Study

• FY05-07 (2 year effort),
  – Independent expert committee (15), Workshops, Interim & Final reports

• Assess
  – Progress in tech base
  – R&D organization
  – Tech transition
  – Long-term SIS maintenance and evolution

• Recommend National-scale SIS S&T investments
  – Collaborate with other Federal investments
Systems and Software Test Track

• Purpose
  – Bring researchers together with developers and development artifacts to ‘test drive’ emerging technologies and techniques

• Activities
  – FY06 – Phase 1 Planning and Definition (6 mos)
    • Scope, funding estimate, programmatic
  – FY07 – Implementation
    • Establish facility
    • Begin populating with developer products,
  – FY08 –
    • Full operations
    • Allow researchers to apply innovative tools, technologies and techniques
Other On-going Activities

- **STTR topics**
  - Error Handling paths and policies analysis
  - Security Escorts for Not-Yet-Trusted software
  - Software System Reliability Analysis
  - Assessing Interoperability Through Cross-Domain Protocol Compatibility Analysis
- **HPEC-SI**
  - Signal processing library

- **SBIR Topics**
  - Design Visualization
  - Malicious Code Diffuser
  - Robust Complex Systems
  - Software Test Engineering: Analysis of Trace Semantics
  - A Software Hub for High Assurance Model-Driven Development and Analysis
  - Software Verification

- **Open Technology Development**
  - Blend of open source and open systems approaches
What We Need . . .

• A 7 year, $20-32M per year investment in software-intensive systems development technologies
  – Research
  – Testing
  – Transition
Return on Investment (ROI)

**Combined Improvement ROI**

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<th>Reduction in Rework</th>
<th>10% Improvement in Productivity</th>
<th>20% Improvement in Productivity</th>
<th>50% Improvement in Productivity</th>
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<td>10%</td>
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• Assumptions
  – New effort, 7 year investment
  – Calculated for 10 future acquisition programs
  – Based on estimated industry productivity\(^1\) and rework for DoD systems\(^2\)

\(^1\) – DACS Software Tech News Volume 7, Number 2 Article “Industry Software Cost, Quality and Productivity Benchmarks” by Donald Reifer, June 2004
DoD Software S&T

• **Current State of Play:**
  - Research investments tailing off
  - Government expertise-base has atrophied
  - Software tools and techniques sometimes developed by acquisition programs themselves
  - CMU Software Engineering Institute focused on SWE process and transition, not advancing technology base

• **Missed Opportunities: No DoD-wide approach to**
  - Working with acquisition programs to address common SW technology issues
  - Developing standards (e.g., CORBA, UML)
  - Engaging 3rd-party software vendors (e.g., Rational (IBM), Mathworks, Green Hills Software)
What about Industry?

- Industry investments are usually inappropriate for DoD problems
  - Research is targeted for specific products, not general long-term improvements
  - Focused on selling software products – quality and reliability are lower priorities
  - Global resourcing for research and development limits applicability to DoD

- For Defense contractors -
  - Software may not be a direct profit driver
  - Software technologies difficult to retain as company IP
Envisioned Program Overview

• **Description:**
  – Reinvigorate SIS development research and provide dedicated efforts to demonstrate and transition improvements to acquisition programs
  – Enable DoD engineers and industry partners to develop and acquire SIS with reasonable and repeatable cost, schedule and performance

• **Benefit:** What is the benefit to the Department?
  – Increase efficiency, reduce cost and schedule overruns, and reduce critical failures associated with software for warfighting and management
  – Successful development of software that meets our growing expectations in software program size and complexity

• **Major Elements:**
  – Research - Technologies, Tools and Techniques
  – Systems and Software Test Track
  – Transition
Previous DoD S&T Investments Have Had a Major Impact

Examples:

- **Real-Time Computing:** an Efficient Principled Approach to Process Task Coordination and Schedulability
- **MoBIES:** Model-Based Integration of Embedded Software for Design and Testing
- **Quorum:** Quality-of-Service Middleware for Robust, Portable Mission-Critical Applications capable of Adapting to the Dynamic, Uncertain Conditions of Network-Centric Warfare
Call for Action

• DoD needs to reinvigorate its investments in software and systems development technologies
  – Increased dependence on software
  – Common problem for acquisition programs

• This Cross-Component issue necessitates a jointly coordinated effort
  – We welcome cooperation with Industry, Academia and other Federal agencies