Software Visualization for System-of-Systems
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GrammaTech

Focus:
› Software analysis and manipulation

Founders:
› Tim Teitelbaum, CEO (Professor Emeritus at Cornell U.)
› Thomas Reps, President (Professor at U. Wisconsin)

Research:
› Various NASA- and DoD-sponsored research projects
› Static and dynamic software analysis
› Applications
  • Safety/Reliability
  • Security
  • Producibility

Products:
› CodeSurfer®, CodeSonar®
› CodeSonar used to check MSL/Curiosity flight code for
  • Bugs and risky code
  • Compliance with JPL coding standard
Some GrammaTech Customers

**Mil/Aero**

- Lockheed Martin
- Northrop Grumman
- Boeing
- MITRE
- SAIC
- NASA
- Airbus
- BAE Systems
- GE Aviation
- Draper Laboratory
- Aerospace Testing Alliance
- CTC
- APL
- Booz Allen Hamilton

**Medical**

- Sonosite
- FDA
- Philips
- intuity Medical
- Calypso Medical
- Hologic
- Cardinal Health
- Storz
- Medrad
- Zoll
- Vertex
- ClonDiag chip technologies
- Cytonome ST

**Industrial Control / Electronics**

- Hyundai
- AutoNet
- Bosch
- Sony
- Fujitsu
- NEC
- Konica Minolta
- Kawasaki
- Rohde & Schwarz
- ST Electronics
- Panasonic
- Furuno
- Q-Free
- EDF
- Synchro
- ASML
- Sprecher Automation
- APC
- ion
- Ingenico
- ABB
- Parkeon

**Telecom/Datacom**

- Qualcomm
- LG
- NTT
- Samsung
- ETRI
- Piolink
- POS Data
- Design Art Networks
- intune Networks
- TTA
- Acciton
- Life’s Good
- packetvideo

No ITAR Material
Spacecraft System Size is Growing

- Exponential growth in spacecraft SW

**Dvorak: NASA Study on Flight Software Complexity**
Automobile System Size is Growing

Dvorak: NASA Study on Flight Software Complexity
Aircraft System Cost is Growing

Augustine’s, not Moore’s law

Software in Military Aircraft

The Economist, Aug 26, 2010

Dvorak: NASA Study on Flight Software Complexity
Project Motivation

- **Problem:** Hard to get a grasp on large software systems
  - DoD: F-22, JSF, FCS
  - NASA: MSL, Orion
  - Network: *Cisco IOS*. 20MLOC.

- **Importance:**
  - Large projects unwieldy, exceed time & cost estimates
  - Examples:
    - F-22, SBIRS-High overruns.
    - Cisco build time (24-36hrs) limits debug/test cycle.
    - How to refactor to optimize build process?
Project Vision

- A canvas for understanding a large system
  - Assessing status
  - Spotting risks
- Works at multiple levels
  - Get an overall view of system of systems
  - Drill-down to subsystem or individual module
- Key: handle very large systems
- Key: easy to use
  - Fits with existing workflow
  - Usable with little or no training
Visualization Tool

- Viewable in web browser
- Search results
- Information about selected node
- Source Listing for selected node
- User can open multiple tabs

Visualization panel supports zoom and pan using mouse.
Visualization Panel Supports Variety of Data Types

Actor model from Ptolemy (UCB)

#include graph in “Boost”

Complex data structure
Techniques

- Adapted from mapping/geographical applications
  - Examples: Google Earth, NASA WorldWind
- Use **graphics hardware** for visualization
- Break information into **layers**
  - Show minimum information needed at that ‘height’
- Pre-process information for quick retrieval later
- Use ‘map’ metaphor
  - Resonates with users
  - Information dense
Building a Map of Software

- Software does not have an obvious 2D representation.
- Use mapping metaphor:
  - Components enclose subcomponents.
    - Eg: packages/classes/methods
- Link nodes by dependency
- Use modern graph layout: yFiles from yWorks
  - Related nodes tend to cluster together
- Sometimes break the map metaphor
  - Change layout strategy: Circular, Radial, Flow
    - Circular: group related nodes
    - Flow: show overall data flow from left to right
  - Delete nodes that are not relevant to you
Underlying Technology

- **Client: Displays just what is needed**
  - Java Applet in standard web browser
  - Java Bindings for OpenGL (JOGL)
  - yFiles layout engine

- **Server: Contains all data**
  - SQLite
  - JSON/RPC
  - HTTP
Scalability

- Wireshark demo: 3.5 million lines of code
- Cisco IOS: 20 MLOC
Availability

- Present in GrammaTech CodeSonar static analysis tool
- Show **call graph** of code being analyzed
- Color by
  - Flaws found
  - Code complexity metrics

- Underlying technology could be applied to any large hierarchical system with internal connections
  - Distributed system
  - Hardware

- Inquire if interested
Conclusion

- **Goal:** Give engineers a space for exploring data at a large scale.

- **Applications**
  - Better understanding of system structure
  - More accurate estimates of modification costs
  - Easier restructuring and identification of bad patterns

- **How:** Leverage mapping techniques
  - Software as a 2D map
    - Break the metaphor a bit
  - Break information into layers
  - Use graphics hardware (OpenGL)
Questions?

- Funded in part by
  - US Army Research Laboratory / Office of Secretary of Defense
  - Naval Research Laboratory

- Contact
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