Extending UML from Software to Systems

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Background

- Increasing system complexity and software content
- Process standards evolving to enhance systems maturity and integration with software
- Need standards for **modeling** complex systems, which bridges software and hardware modeling
- Initiatives underway to address this need
  - ISO 10303 (AP-233) standards effort for SE data interchange and tool interoperability
  - INCOSE / OMG effort to extend UML to systems
SE Modeling Techniques

• **Many proven modeling techniques**
  - Behavior diagrams
  - Data and control flow
  - Functional flow diagrams
  - IDEF
  - N2 charts
  - Schematic block diagrams
  - Signal flow diagrams (control loop)
  - State charts
  - Unstructured (e.g. power-point)

• **Limitations**
  - No broadly accepted standard
  - Scalability to address complexity
  - Do not integrate well with software
  - Lack of extensibility mechanisms
Why UML for Systems Engineering?

- **De-facto standard within the software community**
- **Robust and extensible language to adapt to SE needs**
- **OMG Infrastructure**
  - *Broad international and industry representation*
  - *Defined adoption process to evolve UML*
- **Availability of tool vendor and training support**
Unified Modeling Language

- **UML**
  - *Is a visual modeling language*
  - *Is not a methodology*

- **Visual Modeling Language = Notation + Semantics**
  - Semantics = meaning
  - Notation = representation of meaning
  - Layered meta-model with extension capability

- **Status**
  - Current Version – 1.5
  - UML V2.0 adoption in progress
OMG Systems Engineering Domain
Special Interest Group (SE DSIG)

- Joint INCOSE / OMG Initiative to extend UML to SE
- SE DSIG kickoff in Sept ‘01
- Aligned with ISO AP-233 Systems Engineering data interchange standard to support tool interoperability

- Completed Tasks
  - UML for SE Request For Information
  - Collaboration with UML V2.0 Submission Teams
  - Requirements for UML for SE RFP
UML for SE - Objectives

• **Provide a customization of UML to support modeling a broad range of systems, which include hardware, software, data, personnel, procedures, and facilities.**

• **Support the analysis, specification, design, and verification of complex systems to:**
  – capture the systems information in a precise and efficient manner
  – analyze and evaluate the system being specified
  – communicate systems information correctly and consistently among stakeholders
Summary of Perceived UML 1.x Limitations (Partial List)

- Continuous time behavior
- Decision tree (e.g. support for trade studies)
- Hierarchical modeling of scenarios and behavior
- Input/output flow (including data and mass/energy flow)
- Integration with other specialty engineering models
- Integration with geometric and spatial models
- Parametric relationships (e.g. performance models)
- Performance and physical characteristics (incl probabilities)
- Physical interfaces and connections
- Problem definition and causal analysis
- Requirements constructs
- System, subsystem, element & component representations
- Terminology harmonization
- Verification and validation results
UML V2.0 Support for SE

- Allows for more flexible system and component representations
- System and component interconnection (ports, connectors)
- Behavior decomposition (lifeline decomposition)
- Enhancements to Activity diagrams (data and control flow constructs, activity partitions/swim lanes)
- Enhancements to Sequence diagrams (alt sequences, reference sequences, interaction overview, timing diagram)
UML V2.0 Support for SE (cont.)

- Supports information flows between components
- Does not preclude continuous time varying properties
- Improved profile and extension mechanisms
- Support for model interchange
- Defined compliance points for optional tool support
UML 2 Diagram Types

- Behavior Diagram
  - Activity Diagram
  - Interaction Diagram
    - Collaboration Diagram
    - Interaction Overview Diagram
  - Interaction Overview Diagram
  - Sequence Diagram
- Structure Diagram
  - Use Case Diagram
  - State Machine Diagram
  - Component Diagram
  - Deployment Diagram
  - Composite Structure Diagram
- Class Diagram
- Timing Diagram
- Object Diagram
- Package Diagram

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Composite Structure Diagram Example
UML for SE Request For Proposal

- Specifies requirements for SE modeling language

- Joint requirements reviewed by OMG/INCOSE/AP-233

- Issued by OMG on March 28, 2003
  - OMG Doc # ad/03-03-41
  - http://syseng.omg.org/UML_for_SE_RFP.htm

- Schedule
  - Initial Submissions - October 2003
  - Revised Submissions – March 2004
UML for SE RFP
Modeling Requirements

- **Structure** (e.g. system hierarchy, interconnection)
- **Behavior** (e.g. function-based, state-based)
- **Properties** (e.g. parametric models, time varying attributes)
- **Requirements** (e.g. req’ts types, traceability)
- **Verification** (e.g. test cases, verification results)
- **Other** (e.g. integration with simulation and analysis)
Challenges to Adopting UML for SE

- Developing a robust modeling language that addresses the broad system modeling requirements
- The evolution of model based methodologies
- Acceptance of the model based approach by the SE community, implementers, and customers
- Ability to integrate the SE models with other discipline-specific models (i.e. software, hardware, simulation and analysis, etc)
- Ensuring adequate infrastructure to support the use of models, including tools and training
- Continued adaptation and evolution of the modeling language
Summary

• Need a system modeling language to address system complexity and bridge systems & software gap

• Extending UML has the potential to provide a core systems modeling capability

• INCOSE/OMG established SE DSIG with broad participation to extend UML from software to systems

• UML for SE RFP issued March 2003

• Expected adoption of a standard systems modeling language in 2004
References

• **OMG SE DSIG Site:** [http://syseng.omg.org](http://syseng.omg.org)

• **UML for SE RFP Page (with references to UML 2 submissions)**

• **OMG Site:** [http://www.omg.org](http://www.omg.org)