Architecting Real Time Systems Using UML-PPOOA Process, Guidelines and Tool

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Proposed Approach: Agility + Quality

• An agile design must be continually verified, in the same manner that the implementation must be continually tested. Verification must occur from two perspectives:
  – agreement between design and the implementation
  – verification that the design meets quality requirements

• The design should address how each quality requirement is satisfied. This should include a discussion of the intent of each design element, in the context of any applicable abstract models that were developed\(^1\)

\(^1\) Assurance & agile Processes. Does agility conflict with security or reliability? Cliff Berg and Scott Ambler. DrDobb’s Journal July 2006
Content

• PPOOA
• PPOOA building elements
• PPOOA Architecting Process (PPOOA_AP)
• PPOOA_AP Guidelines
• Experiences of using PPOOA and PPOOA_AP
• PPOOA implementation on Visio CASE tool
• Next PPOOA tool features
• To conclude
• A model based approach for architecting real-time systems
  – Based on UML notation
  – Supports a diversity of components and coordination mechanisms (for synchronization and communication) not found in UML.
  – Describes the system architecture using two views: one structural view (UML class diagram), and one behavioral view (UML activity diagram)
  – It is supported by an architecting process (PPOOA_AP), defining the steps to build the architecture
  – A CASE tool (PPOOA-Visio) may be used
PPOOA Building Elements

Components

PPOOA

Coordination

Mechanisms

CFAs or System responses
Components included in PPOOA vocabulary

Controller:
Manages external events

Domain component/Algorithmic component:
Performs operations

Structure:
Maintains relations between objects

Process:
Coordinates work to others
Coordination Mechanisms support two major issues of real-time systems: *synchronization* of flows of activities and *asynchronous communication* between the components of the system.

*Synchronization* is the blocking of a process until a certain condition is met.

*Communication* is the transfer of information between components.
Coordination Mechanisms included in PPOOA vocabulary

- Bounded Buffer
- Mailbox
- Transporter
- General Semaphore
- Rendezvous
CFA or System response (I)

DEFINITION

CFA means Causal Flow of Activities. Therefore, a CFA is a chain of activities that is triggered by an event.

[Diagram with nodes labeled A1, A2, A3, A4, A5, A6, A7, and annotations for triggering event, scheduling points, and continuation element]
PPOOA_AP: PPOOA Architecting Process
Why a new architecting process?

• Traditional CBD and OO architecting approaches focus upon producing encapsulations and abstractions for system componentry.

• The effort of the resulting architecture on the ability of a system to meet its time responsiveness expectations requires additional understanding well beyond functionalities and their combined computational timing requirements.

• Concurrency modeling and synchronization behavior become a dominant concern early in the architecture development whenever time is a critical factor.

• Object definition and collaboration strategies should reflect meaningful timing constraints.
PPOOA Architecting Process

1. Identify Components
2. Define Component Interfaces
3. Describe System CFAs
4. Select Coordination Mechanisms

INPUTS:
- Use Cases
  - Description (including scenarios)
- System Domain Model
  - (UML Class diagram notation)

OUTPUTS:
- PPOOA Architectural Diagram
- PPOOA Dynamic View (CFAs)

INPUTS

OUTPUTS

1. Identify Components
   - Split Components

2. Define Component Interfaces

3. Describe System CFAs

4. Select Coordination Mechanisms
   - Split Components

INPUTS

OUTPUTS

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• Architecture design principles and component selection criteria are described as guidelines or tactics

• 25 guidelines are proposed in PPOOA_AP document
Groups of Guidelines

• Guidelines relative to PPOOA Architectural Style
• Guidelines relative to the Use of PPOOA Components
• Guidelines relative to the use of PPOOA Coordination Mechanisms
• Guidelines for CFA Construction
• Guidelines for process Scheduling
Experiences of Using PPOOA and PPOOA_AP

• Diverse systems were developed using PPOOA and PPOOA_AP architecting approach

  – SCADA (Supervisory Control and Data Acquisition) System developed at UPM (Spain).

  – Underwater Autonomous Robot developed by Qinetiq (UK) and presented at ICSSEA 2002.

  – Space System developed by ARTAL (France) as part of CARTS, 5th Framework Programme, IST funded project (IST-1999-2068).

  – Airbus A400, some avionics functionalities developed by CASA-EADS (Spain) (Since May 2005).
Implementing PPOOA in Microsoft Visio
Microsoft Visio

• A Visio solution is a combination of Visio shapes and programs that model the real world and solve specific modelling problems

• A Visio solution usually includes:
  – **Stencils** of master shapes
  – **Templates** that provide stencils of specific shapes
PPOOA - Visio
( Modelling a System Architecture Diagram)
PPOOA - Visio
( Modelling a Subsystem Architecture Diagram)
PPOOA – Visio

(Modelling a system response, “CFA Diagram”)
PPOOA-Visio (Tool Features)

- Automatic generation of documentation
- Automatic model checking based on PPOOA building guidelines
- Contextual help
Automatic generation of architecture documentation

• The PPOOA Visio Tool generates automatically the documentation of the system architecture developed
  – Description of each building element, its domain attributes, interface and real time attributes
  – Generated in HTML format
Automatic Model Checking based on PPOOA building rules

• The PPOOA-Visio tool supports automatic checking of PPOOA building guidelines
  – Composition relations between two building elements
  – Dependency (“usage”) relations between two building elements
Checking PPOOA Rules
PPOOA-Visio Help

- PPOOA architecting method PPOOA_AP is implemented as part of the Visio help and in a contextual form
  - Architecting process steps
  - Description of the PPOOA building elements
  - Composition rules
  - Dependency rules
  - References to other documents and papers
Contextual help

Architectural Diagram

Process

1. Abstraction supported

The process is a building element of the architecture that implements an activity or group of activities that can be executed at the same time as other processes. Its execution can be scheduled.

Attributes:
- Execution time of each activity.
- Priority.
- Shared resources (blocking, non-blocking, etc.).
- Other attributes (optional).

PRODA-OAS support.
Next tool features

• Implement performance engineering and “time response analysis” (RMA) capabilities
• Implement import and export mechanisms (XMI) to other CASE tools and Integrated Development Environments
• Improve automatic evaluation of models
• Create and implement a “developer assistant” that will help novice users to apply the PPOOA method and tool.
To Conclude (I)

• PPOOA is an architectural style that solves some **UML limitations**.
  • better support for CBD (Taxonomy of Components)
  • emphasizes coordination mechanisms usage
  • allows time responsiveness assessment (by using CFAs models)

• PPOOA is complemented by an architecting process called **PPOOA_AP**.
  • major and minor steps to be followed
  • guidelines or strategies to be applied

• PPOOA is already implemented in a well known **CASE tool** *(Microsoft Visio 2003)*
To Conclude (II)

PPOOA supports the easy adoption by industry of Real Time and Embedded Systems architecting techniques:

- A free trial version of PPOOA tool is offered by request
- Free publications and reports may be downloaded from ppooa web page (www.ppooa.com.es)
- On-site training dealing with UML and PPOOA may be negotiated per customer
- Maintenance of PPOOA tool may be negotiated per customer
- Consultancy dealing with PPOOA adoption (pilot project + next steps) may be negotiated per customer
Contact us

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