Query Based UML Modeling

Validation and Verification of the System Model and Behavior for a Hydraulic Crane

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ENPM 643
Instructor: Dr. Mark Austin
Systems Engineering Process for a Hydraulic Crane

- Link Belt ATC 3200
  - Requirements
  - Systems Structure
  - System Behavior
  - Constraints
  - System Allocation
  - Verification

UML Query Tool

- Validation
- Query Modeling
Five Operational Phases of a Crane

- Pre-Start Initiation
- Handling and Attaching the Load
- Lifting the Load
- Maneuvering the Load
- Ending Lifting

Nominal and Off-Nominal Use Cases in UML *

- Nominal: positive use cases
- Of-Nominal: negative use cases

* Reference – Uchitel Implied-Scenario
Constraints and Assumptions

- Crane Type: Only all-terrain mobile cranes are considered for this report.
- Risk: Only safety-related risks are evaluated and analyzed for the failure analysis.
- Operation: Only stationary crane operations are considered for this report.
- Analysis: The level of analysis for this case study is constrained at the operational level.
Operational Sequence

Phase 1: Initiate Pre-Start Inspection
Phase 2: Handle & Attach the Load
Phase 3: Lift the Load
Phase 4: Maneuver the Load
Phase 5: End Lifting
## Inheritance Diagram

### CRANE MAIN SYSTEM

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boom Length</td>
<td>Hook Strength</td>
</tr>
<tr>
<td>Counterweight</td>
<td>Clutch Integrity</td>
</tr>
<tr>
<td>Rotex Gear Strength</td>
<td>Joystick Movement</td>
</tr>
<tr>
<td>Jib Length</td>
<td>Pre-Start Initiation</td>
</tr>
<tr>
<td>Outrigger Integrity</td>
<td>Handle and Attach</td>
</tr>
<tr>
<td>Boom Level Indicator Integrity</td>
<td>Lift</td>
</tr>
<tr>
<td>Cable Strength</td>
<td>Maneuver</td>
</tr>
<tr>
<td></td>
<td>End Lift</td>
</tr>
</tbody>
</table>

### CRANE SUBSYSTEM

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guard Integrity</td>
<td>Drum Integrity</td>
</tr>
<tr>
<td>Turntable Movement</td>
<td>Motion Control Movement</td>
</tr>
<tr>
<td>Tire Pressure</td>
<td>Hydraulic Pump Pressure</td>
</tr>
<tr>
<td>Hydraulic Cylinder Leakage</td>
<td>Pre-Start Initiation</td>
</tr>
<tr>
<td>Hydraulic Filter Integrity</td>
<td>Handle and Attach</td>
</tr>
<tr>
<td></td>
<td>Lift</td>
</tr>
<tr>
<td></td>
<td>Maneuver</td>
</tr>
<tr>
<td></td>
<td>End Lift</td>
</tr>
</tbody>
</table>
Initial Use Case Diagram

ACTOR
- Crane Operator
- Signalman
- Oilman

CRANE
- Initiate Pre-Start Inspection
- Handle and Attach the Load
- Lift the Load
- Maneuver the Load
- End Lifting
Phase 3

1. Ensure suspended load area is clear
   - Suspended load area clear

2. Ensure clear swing path
   - Clear swing path

3. Ensure dynamic weather effects are in control
   - Dynamic weather effects controlled

4. Ensure boom level indicator is working
   - Boom level indicator works

5. Ensure load is not rotated
   - Load not rotated

6. Engage clutch
   - Clutch engaged

7. Engage joystick
   - Joystick engaged
Phase 4

T = 1
Restrain sudden acceleration and deceleration

Sudden acceleration and deceleration restrained

T = 2
Ensure crane structure is protected against boom and jib rotation

Crane structure protected

T = 3
Restrain empty hooks

Empty hooks restrained

T = 4
Carry boom in line with direction of motion

Boom carried in line with direction of motion

T = 5
Engage clutch

Clutch engaged

T = 6
Engage joystick

Joystick engaged
Phase 5

1. Land any load
   - Load landed

2. Secure crane against accidental travel
   - Crane secured

3. Put controls in the off or neutral position
   - Controls in off or neutral position

4. Set brakes
   - Brakes set

5. Disengage master clutch
   - Master clutch disengaged

6. Stop engine
   - Engine stopped
Off-Nominal Use Case Scenario

FMEA Analysis
- Cause and Effect Hazard Analysis
- Positive and Negative Use Cases
- Allocation of Negative to Positive Use Cases

Benefits
- Robustness in Design
- Pinpoint Design Flaws
- Error Proof
Requirements

Requirements based on Manufacturers Operational and Design Specifications

Operational Requirements used to create Main and Derived requirements

Requirements Verification Matrix used to verify design meets requirements specifications

Requirements Constraint and Analysis analyzes extent and implementation of requirements
Query Modeling and Validation

UQLAT – UML Query and Link Analysis Tool
  - Queries and dynamically links block elements of UML diagram
  - Currently limited to Activity diagrams

Data Structure
  - Block Element data structure as an element into processing algorithm
    - Block ID - Input
    - Name - Output
    - Level - NOI
    - Phase - NOO
    - Time Element - Recursive
    - Action/State - Pointer
Query Event Sequence

- Query using GUI
- Database Processing
- Algorithm Processing
- Query Display in GUI
Query Types

- Query any one element within one phase
- Query one element independently across many phases simultaneously
- Query all the inputs from any one element within one phase
- Query all the outputs from any one element within one phase
- Query the link between any one element and other elements within one phase
- Query the level of any element within any phase
Query Initiation Form

Program ID: HC 2671 - UQTAL QIF Hydraulic Crane UML
Query Mode: AC 1 - Activity Diagram Status: UNCLAS Date: 12-04-06
User ID: DMathew Type: ORDAT 2

Search Name Box: xxxxxxxxxxxxxxxxxxx
Input: 

Level: 
Output: 

Phase: 
NOI:

Time Element: 
NOO:

Action/State: 
Recursive: 

Pointer: xxxxxxxxxxxxxxxxxxx
SAVE
PREVIEW
QUERY?
Query Results Form

<table>
<thead>
<tr>
<th>Program ID:</th>
<th>HC 2671 - UQTAL QIF</th>
<th>Status: UNCLAS</th>
<th>Date: 12-04-06</th>
<th>User ID:</th>
<th>DMatthew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query Mode:</td>
<td>AC 1 - Activity Diagram</td>
<td></td>
<td></td>
<td>Type:</td>
<td>ORDAT 2</td>
</tr>
</tbody>
</table>

**Input Parameters:**
- Primary Key – Block ID
- Secondary Key – Phase 2

**Output:**
- Total Elements: 18
- Action Elements: 9
- State Elements: 9

**Block ID:**
- Action - BLB-ACD-01 BLB-ACD-02 BLB-ACD-03 BLB-ACD-04 BLB-ACD-05 BLB-ACD-06 BLB-ACD-07 BLB-ACD-08 BLB-ACD-09

**DIAGRAM LINK**

**QUERY ?**