RESEARCH REVIEW 2020

TwinOps – Digital Twins Meet DevOps

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Cyber-Physical Systems still exhibit misbehaviors after field tests. Their engineering relies on models built in isolation, limiting in-depth unit and integration testing until the system is done. We are combining DevOps and Model-Based Engineering to build and deploy systems and their Digital Twins. TwinOps combines system, software, and physical models to improve system analysis.
Create the best design that holds up over time as the system evolves. + Test the design without having to write any code. = Build a single model to assess hardware and embedded software before the system is built.

**SAE AADL / ACVIP**
Standardized language and process for the engineering safety-critical systems.

**OSATE**
Open Source AADL toolset for performing verification and validation (V&V).

**DoD Transitioning**
Maturity increased through pilot projects and trainings.
TwinOps Problem Space: CPS Integration and Testing

TwinOps: leverage other source of truth (e.g., CAD, Physics) to improve SW V&V
⇒ Use precise models instead of (naïve) abstractions for improved SW V&V
⇒ Combine domains, including SysEng
Models – An Overview

Models are *abstractions* that address specific concerns.

<table>
<thead>
<tr>
<th>Static Architecture</th>
<th>Dynamic Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Definition</td>
<td>Activity Sequence</td>
</tr>
<tr>
<td>Internal Block</td>
<td>State Machine</td>
</tr>
<tr>
<td></td>
<td>Use Case</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Informal</th>
<th>Formal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Definition</td>
<td>AADL</td>
</tr>
<tr>
<td>Internal Block</td>
<td>Modelica</td>
</tr>
<tr>
<td>Activity Sequence</td>
<td>SCADE Suite®</td>
</tr>
<tr>
<td>State Machine</td>
<td>SIMULINK</td>
</tr>
<tr>
<td>Use Case</td>
<td>ANSYS®</td>
</tr>
</tbody>
</table>
Technology Focus: Models and Code Generation

One can **generate code** from models ready to be embedded in the system (e.g., AADL to C) and get insights from the system to refine the model metrics.

One can **simulate models** and generate simulation code as a mock-up of some system parts.

One can build **Digital Twins**, that compare actual system and its digital simulated doppelganger.
From DevOps to ModDevOps

DevOps delivers software faster with increased quality:
• Continuous integration/deployment
• Containerized systems

DevOps is a software process, to be adapted to systems.

“ModDevOps is a systems/software co-engineering culture and practice that aims at unifying systems engineering (Mod), software development (Dev) and software operation (Ops). The main characteristic of the ModDevOps is to strongly advocate abstraction, automation, and monitoring at all steps of system construction.”

(adapted from https://software.af.mil/training/devops/ )
ModDevOps in Action – Modeling Process

- 0. SysML
- 1. AADL
- 2. Controller (Simulink)
- 3. AADL
- 4. C

SCM

- AADL-to-C
- Simulink-to-C
- C-to-binary
- Deploy binary

Mod2code Pipeline
From ModDevOps to TwinOps

1-2-3-4: “mega-modeling” V&V
- 1-2: HLR validation
- 2-(3+4): validation of LLR
- 1+(3+4): virtual integration

Digital Twins

0. SysML
1. Plant (Modelica)
2. Controller (Simulink)
3. AADL
4. C

Digital Twins of UAV vs. UAV flying: validation of Modelica model, efficiency of the controller (overshoot verification) and timing verification of software.
ModDevOps in Action – ModDevOps Pipeline #2

Mod2code pipeline

- SCM
- AADL-to-C
- Simulink-to-C
- C-to-binary
- Deploy binary

Mod2simu pipeline

- SCM
- Modelica-to-FMI
- FMI-to-AADL
- Mod2code
- Run simulation
From ModDevOps to TwinOps

- SCM
- Mod2Code
- Cloud Deployment
- Mod2Simu
- Digital Twins
- Modeling Process

Mod/Dev
Ops/Digital Twins
TwinOps: Continuous System Improvement through ModDevOps and Digital Twins

1. Plan requirements and properties
2. Modeling architecture and parts
3. Virtual integration
4. Code generation run-time observers
5. Testbench assembly
   - Simulation
   - Instrumented platform
6. Run || Simulate
7. Monitor
8. Data Analysis
With TwinOps, the SEI delivered a ModDevOps exemplar, bridging Model-Based Systems Engineering and Software Engineering.

TwinOps improves analysis and testing capabilities by leveraging multiple models and combining them.
TwinOps Team Members

To learn more or collaborate, contact us at info@sei.cmu.edu.