ENSEMBLE Embedded Software Integration Platform

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INTRODUCTION
Engineers face numerous challenges:

- Accelerated path to production
- Diversity in deployment ecosystems
- Wide variety of target hardware platforms
- Need for complex interoperability
- Diversity in business application spaces

GE Research developed an embedded software integration platform called Ensemble, which helps engineers:

- to maximize the use of automation and code generation to take over mundane development aspects
- to enable engineers to spend more time developing core functionality, and less time focused on intricacies of deployment
- to facilitate team collaboration, testing, verification, and maintenance of embedded applications
Ensemble Platform Applications

Ensemble platform has been used by the following GE projects
- GE Power Digital Ghost program for cyber-security power generation infrastructure protection
- GE Digital power grid state estimation and monitoring
- GE Renewable Energy Grid Automation Controls Software Platform
- GE Research ARPA-E building control automation program
- GE Research DOE coal power plant advanced control program
- GE Research Controls and Optimization infrastructure development project
Automation of Adaptive HVAC Building Control

AWS Cloud
- Aggregator: global MPC update
  - Node Controller: local MPC iterations
    - Estimator (UKF): building model
      - Setpoint Calc: Chiller power → Temp. SP
        - Data I/O: Receive sensor data, Send setpoints
          - Algorithm development & testing in Matlab/Simulink
            - Deployment through container micro-services in Linux on Intel NUC
              - Edge-cloud communication via MQTT protocol, KMC API

ENBALA/KMC Cloud
- Real-time sensor data
- Setpoint commands
  - Building Management System
ENSEBLE PLATFORM APPLICATION EXAMPLE DEMO

DEPLOYING F14 ELEVATOR CONTROLLER IN A DOCKER CONTAINER
Deploying F14 elevator control application

F14 Elevator Control Example from Simulink Demo Suite

Controller

Actuator Model

Aircraft Dynamics Model

Dryden Wind Gust Models

Stick Input (in)

Sticker Command (deg)

q (rad/sec)

num(s)/den(s)

Elevator Deflection d (deg)

Vertical Velocity w (ft/sec)

Vertical Gust wGust (ft/sec)

Pitch Rate q (rad/sec)

Rotary Gust qGust (rad/sec)

1/\text{Uo}

w

q

\text{Pilot g force (g)}

\text{Nz pilot calculation}

\text{Pilot G force Scope}

\text{Nz Pilot (g)}

\text{Nz pilot calculation}

\text{Angle of Attack}

\text{alpha (rad)}

\text{Ready}

\text{Sample based}

T=60.000

\text{Ready}

\text{Sample based}

T=60.000
Deploying F14 elevator control application
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ENSEMBLE PLATFORM OVERVIEW
Architecture Modeling Phase

- Enterprise Architect
- Magic Draw
- IBM Rational Rhapsody
- MathWorks System Composer
Component Implementation Phase

- Matlab / Simulink /Stateflow
- C / C++ / FORTRAN /Ada (compiled languages)
Integrated Testing Phase

- Simulink
- System Composer
Deployment Phase

- Real Time / Embedded Target / Containerization Infrastructure
ENSEMBLE integration Platform as a Service ( iPaaS)
Summary

- Ensemble is the Embedded Software integration Platform (ESiP) for MATLAB/Simulink/Stateflow/C/C++ based applications.
- It uses automation, code generation and a variety of common middleware implementations to simplify production of large sets of embedded application microservices.
- Use of this platform substantially increases productivity of embedded software development teams.
- It reduces the need of development teams to perform costly manual integration steps and allows them to focus on core embedded system capabilities and not on integration issues.
- This platform paves the way to better Continuous Integration and Continuous Delivery (CI/CD) paths for embedded software applications.
Additional Resources

A detailed application case study using Ensemble platform can be found in:

In depth examination of the Ensemble platform can be found in:
N. Visnevski, "A Novel, Model-Based, Specification-Driven Embedded Software Integration Platform“, 2021 Aerospace Conference

In depth analysis of deployment aspects of the platform can be found in: