Design and deploy Service-oriented Architectures (SOA) in Simulink

Shwetha Bhadravathi Patil     Aastha Kanwar     Mark Danielsen              Luigi Milia
Agenda

▪ Evolution of architectures and key challenges

▪ Simulink for service-oriented architectures (SOA)

▪ Simulink support for SOA industry standards
  – Simulink for AUTOSAR Adaptive
  – Simulink for Data Distribution Service (DDS)

▪ Conclusions and key takeaways
The rush for Gold Software

From the news...

- **General Motors** Adds 3,000 New Tech Jobs to Boost Virtual Testing and Software Expertise

- **Volkswagen’s** Boss Warns the Troops: We Don’t Want to End Up Like Nokia

- **Daimler** to Cut Out Suppliers to Fund Software Hiring Spree

- **Continental and Amazon Web Services** Create Platform for Automotive Software

- **Bosch** Consolidates All Automotive Software And Electronics Into New Division

https://www.ft.com/content/6173af2c-2ea8-4e90-876a-5cc189e3342b
Industry trends

Key enablers:

1. Centralization of computing power into high-performance, on-board computers
2. New approach to E/E and software architectures
Evolution of E/E architectures

Distributed

- ~100 ECUs
- One function per ECU
- Heavy and long wiring

Consolidation

- Domain controllers
- Multi-core ECUs
- Gateways and networks

Performance-Connectivity

- Vehicle/zone controllers
- High-performance CPUs (Many-core, GPU, FPGA)
- High-speed ethernet
Towards service-oriented architectures

- High SW-HW coupling
- No standard APIs
- No/minimal SW reuse

- Static SW component allocation (design-time)
- Signal-based communication
- HW abstraction
- Monolithic update (full image flashing)

- Dynamic Service discovery (run-time)
- Service-oriented communication
- Higher HW abstraction
- Selective updates (OTA)
SOA – What’s it all about?

- SOA consists of services that communicate across different platforms over messages.

- SOA provides flexibility to add, remove, or update components without impacting the entire, typically large, software system.

- SOA is used by multiple industrial standards including:
  - AUTOSAR Adaptive Platform
  - DDS (Data Distribution Services)
  - ROS (Robot Operating System)
Key challenges

- Service-oriented applications are still new for Automotive industry
- Coexistence of legacy and SOA architectures
- Reuse of existing expertise, workflows and software assets (don’t start from scratch)
Simulink: Deploy software to different targets and standards

- Legacy ECU
- Software
- Hardware

- AUTOSAR Classic
  - RTE
  - Basic Software
  - Application Software

- AUTOSAR Adaptive / ROS / DDS
  - Basic Services
  - Middleware
  - Application Services

- μC
- FPGA
- GPU
Poll Question #1

Are you already working on SOA based applications? (Check all that apply)

   Yes, I’m working on a production or pilot project
   Yes, I plan to reuse existing Simulink models / use MBD for SOA
   No, but I’m going to work on SOA in near future
   No, I’m not planning to work on SOA
Agenda

- Evolution of architectures and key challenges
- Simulink for service-oriented architectures
- Conclusions and key takeaways
Simulink Messages for Service-oriented communication

You can model service-oriented communication using messages (Send/Receive).
Bus Support for Messages

- Message lines can be combined via a bus
- Can use a queue on the bus
- Accessed either via a bus selector or bus element port
Message Merge

- Combine multiple message lines into a single message line
- Specify both nonvirtual and virtual buses to carry Messages.
Event-Based Logging and Animation

- Inspect and animate events in the model involving:
  - Function-Call Subsystems
  - Simulink Messages
  - Simulink Functions

- Using
  - Event Logging
  - Event Animation
  - Sequence Viewer tools.
Agenda

- Evolution of architectures and key challenges
- Simulink for service-oriented architectures (SOA)
- Simulink support for SOA industry standards
  - Simulink for AUTOSAR Adaptive
  - Simulink for Data Distribution Service (DDS)
- Conclusions and key takeaways
AUTOSAR Adaptive Platform implements the AUTOSAR Runtime for Adaptive Applications (ARA) for automotive industry.

Model, simulate, test and generate code for AUTOSAR Adaptive applications in Simulink.
Simulink support for AUTOSAR Adaptive

- In AUTOSAR Adaptive, services implement **communication** through:
  - Events
  - Methods
  - Fields

- In Simulink, **Events** can be modeled as **Messages** and then configured for code generation using **AUTOSAR Blockset**.

**AUTOSAR Adaptive C++ compliant code is generated by Embedded Coder.**
Adaptive SW architecture concepts

```
"Radar" : {
   // events
   "event" : {
      "leftLaneDistance"
      "leftTurnIndicator"
      "leftCarInBlindSpot"
      "rightLandDistance"
      "rightTurnIndicator"
      "rightCarInBlindSpot"
   },
   // methods
   "method" : {
      "Calibrate"
      "Adjust"
   },
   // fields
   "field" : {
      "updateRate"
   }
}
```

```
"Hazard" : {
   // events
   "event" : {
      "leftHazardIndicator"
      "rightHazardIndicator"
   },
   // methods
   "method" : {
   },
   // fields
   "field" : {
   }
}
```
Modelling an AUTOSAR Adaptive application in Simulink

```
"Radar": {
  // events
  "event": {
    "leftLaneDistance"
    "leftTurnIndicator"
    "leftCarInBlindSpot"
    "rightLaneDistance"
    "rightTurnIndicator"
    "rightCarInBlindSpot"
  },
  // methods
  "method": {
    "Calibrate"
    "Adjust"
  },
  // fields
  "field": {
    "updateRate"
  }
}
```
Modelling an AUTOSAR Adaptive application in Simulink

```json
"Hazard" : {
  // events
  "event" : {
    "leftHazardIndicator",
    "rightHazardIndicator"
  },
  // methods
  "method" : {
  },
  // fields
  "field" : {
  }
}
```
Dynamic Service Discovery

Find adaptive services by using dynamic discovery

- Configure AUTOSAR adaptive applications to **discover and subscribe to adaptive services** as they become available

- You can also configure service port programmatically as OneTime or DynamicDiscovery

```matlab
apiObj = autosar.api.getAUTOSARProperties("autosar_LaneGuidance");
apiObj.set("/LaneGuidance_pkg/LaneGuidance_sw/LaneGuidance/RequiredPort/", "ServiceDiscoveryMode", "DynamicDiscovery")
```
AUTOSAR Adaptive workflows

Export ARXML

Import ARXML

AUTOSAR
Adaptive
Architecture

SW-C
Description

Simulink,
AUTOSAR Blockset

Embedded
Coder

Application SW
C++ Code

Export ARXML

Import ARXML

Top-Down

Bottom-Up
AUTOSAR Adaptive in action

- Create model from ARXML
AUTOSAR Adaptive in action

- Create model from ARXML

- Configure Service Discovery

  Subscribe to adaptive services
  - Only at startup, or
  - Dynamically, as they become available
AUTOSAR Adaptive in action

- Create model from ARXML
- Configure Service Discovery
- Verify AUTOSAR properties
AUTOSAR Adaptive in action

- Create model from ARXML
- Configure Service Discovery
- Verify AUTOSAR properties
- Generate code
AUTOSAR Adaptive in action

- Create model from ARXML
- Configure Service Discovery
- Verify AUTOSAR properties
- Generate code
AUTOSAR Adaptive in action

- Create model from ARXML
- Configure Service Discovery
- Verify AUTOSAR properties
- Generate code

Integrate Applications with third party Adaptive stack
Poll Question #2

Are you working on AUTOSAR Adaptive applications? (Check all that apply)

- Yes, I'm working on a production or prototyping project
- Yes, I'm using Model-Based Design for AUTOSAR Adaptive
- Yes, I'm writing C++ code for AUTOSAR Adaptive
- No, but I'm going to work on AUTOSAR Adaptive in near future
- No, I'm not planning to work on AUTOSAR Adaptive
Data Distribution Services (DDS) uses SOA methodology, and directly addresses publish and subscribe communications for real-time and embedded systems.

DDS addresses the needs of applications that require real-time data exchange in industries like aerospace and defense, automotive, and robotics.
How does DDS Blockset Work?

Conceptual DDS Blockset Workflow

Start with a DDS network and the DDS definitions
Create DDS definitions
Configure DDS interface
Deploy Applications to DDS Network
User Workflow with UI Steps

1. Import
2. DDS UI
3. DDS UI
4. DDS UI
5. Generate
6. Deploy

- Interface definitions
- QoS definitions
- (XML)
- Creates
- From central repo
- DDS Databus
- IDL/XML + Vendor support
DDS Blockset in action

- Import DDS definitions from XML or create new Definitions
DDS Blockset in action

- Import DDS definitions from XML or create new Definitions
- Define/Modify DDS definitions in DDS Dictionary
  - Topic Types
  - Domains
  - QoS
DDS Blockset in action

- Import DDS definitions from XML or create new Definitions
- Define/Modify DDS definitions in DDS Dictionary
- Model applications

Use DDS Blocks to model a Publisher or Subscriber
DDS Blockset in action

- Import DDS definitions from XML or create new Definitions
- Define/Modify DDS definitions in DDS Dictionary
- Model applications
- Simulate DDS models including QoS

Use Simulink to model and simulation Quality of Services (QoS) policies including history to verify the runtime behavior.
DDS Blockset in action

- Import DDS definitions from XML or create new Definitions
- Define/Modify DDS definitions in DDS Dictionary
- Model applications
- Simulate DDS models including QoS
- Generate DDS executables and deploy on a DDS network

With Embedded coder, generate
- C++ production code with DDS APIs
- XML or IDL files from Simulink models to deploy
DDS Blockset in action

• Import DDS definitions from XML or create new Definitions

• Define/Modify DDS definitions in DDS Dictionary

• Model applications

• Simulate DDS models including QoS

• Generate DDS executables and deploy on a DDS network

Full integration with third-party DDS stacks including RTI Connext and eProsima Fast DDS
Poll Question #3

Are you working on DDS based applications? (Check all that apply)

Yes, I’m working on a production or prototyping project
Yes, I am generating C code from Simulink model configured for DDS
Yes, I am generating C++ code from Simulink model configured for DDS
No, but I’m going to work on DDS in near future
No, I’m not planning to use DDS
Conclusions and Key takeaways

- **Automotive E/E and SW architecture are evolving**, pushed by need for advanced, complex functions

- New, **service-oriented architectures** are required to **master complexity** and enable **frequent updates**

- You can **design, simulate and generate** code to deploy service-oriented applications in **Simulink**

- You can **reuse your existing expertise and models** to mitigate the risk of migration to SOA applications
To learn more, visit the SOA, AUTOSAR & DDS Blockset pages

www.mathworks.com/discovery/soa.html

www.mathworks.com/products/autosar.html

www.mathworks.com/products/dds.html
Learn more by visiting demo showcase and partner talks at the MATLAB Expo

Thomas Kleinhenz - Elektrobit Automotive - Developing a Driver Monitoring System Using Model-Based Design

Francisco González - Vector Informatik - Developing a Driver Monitoring System Using Model-Based Design
Get in touch!

Please, reach out to us! We’ll be happy to work with you and embrace your SOA project together.

Poll - Are you interested in more information?
  a. Yes, I have some questions and would like to talk
  b. Yes, I would like to schedule follow up session on this topic with my team
  c. Not at this time
MATLAB EXPO 2021

Thank you