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 Software. Everyware.



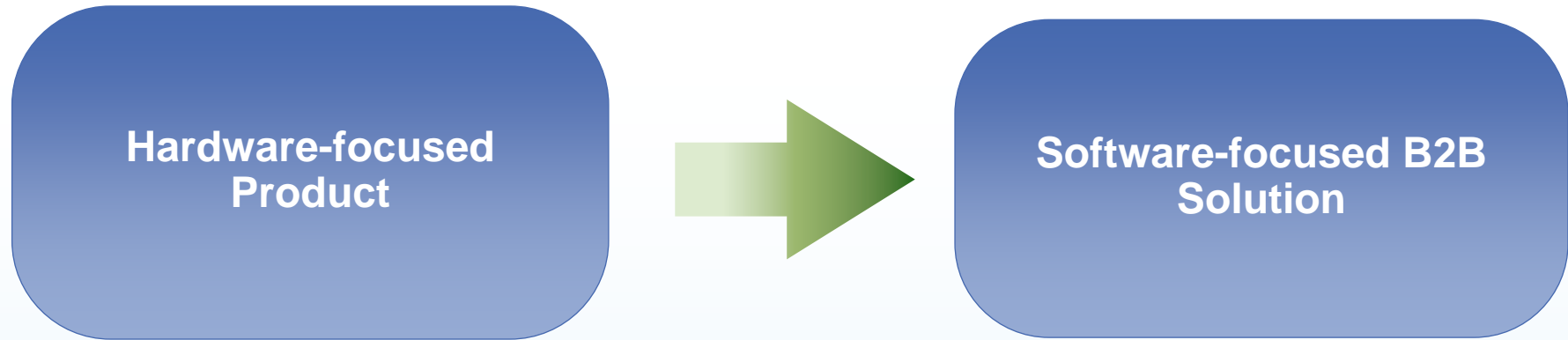
시스템 엔지니어링을 통한 제품 개발 혁신 사례

조재우

수석 연구원

LG전자 HE사업부

Why Model-Driven Development (MDD)?



Business Solutions



Business Solutions Company



Monitor

- LCD Monitor
- Network Monitor
- Digital Photo Frame



Car Infotainment

- Car Audio/Video
- AV Navigation
- Telematics



Security System

- Camera
- DVR
- Security Monitor



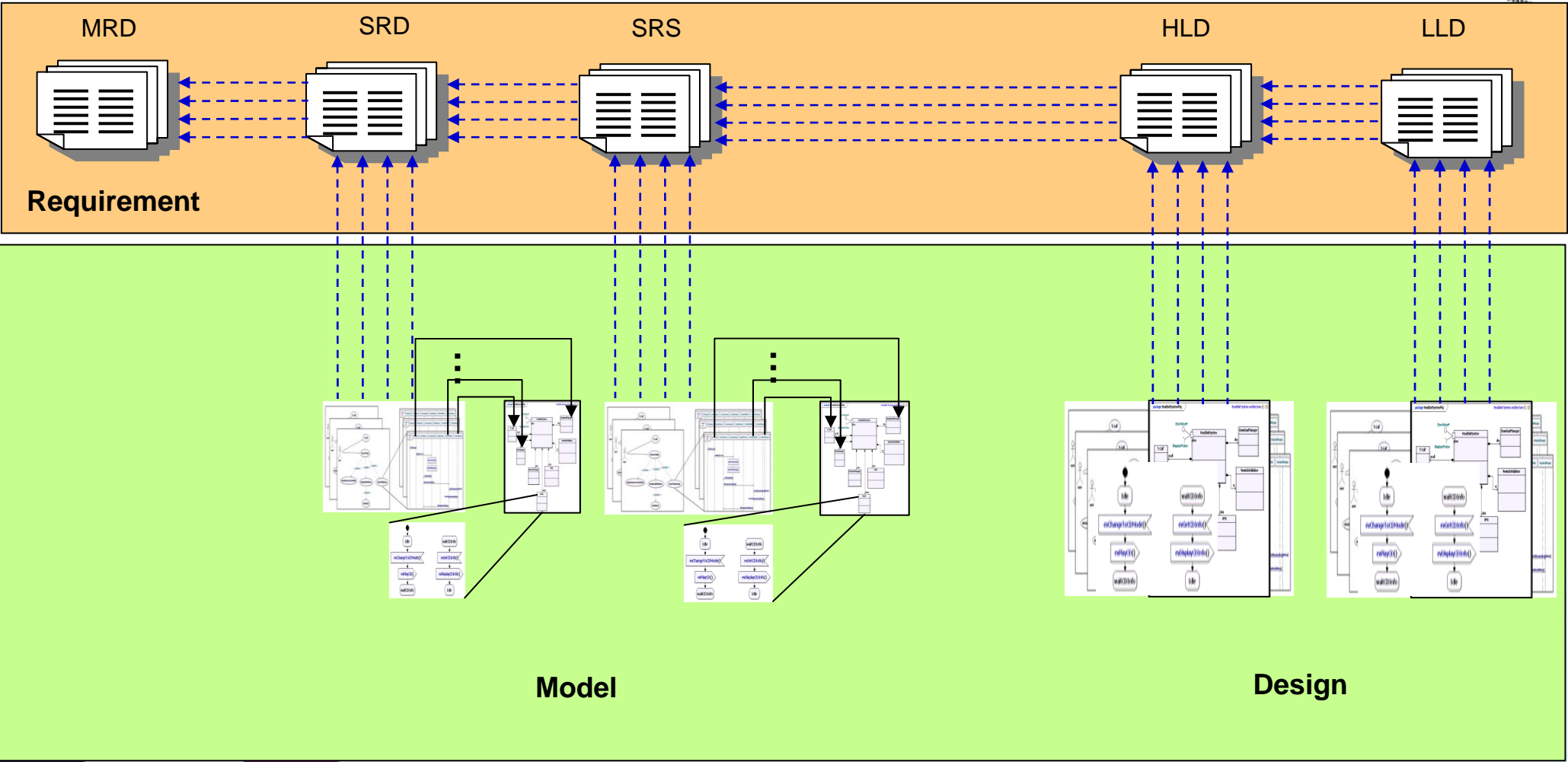
Commercial Display

- Hotel TV
- Digital Signage Display
- Health Care TV

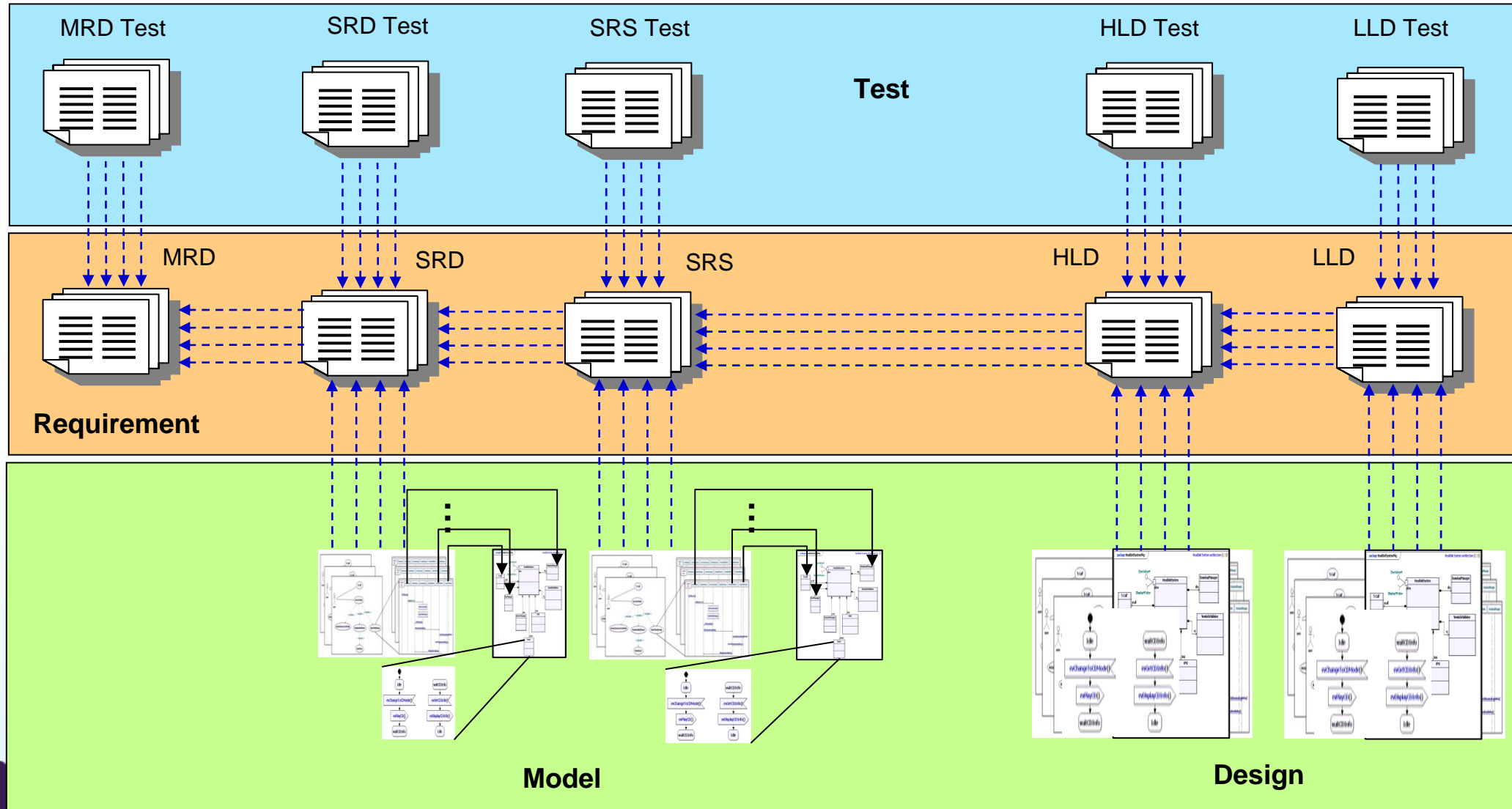


Overview of Traceability

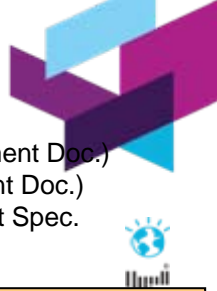
MRD (Marketing Requirement Doc.)
SRD (Solution Requirement Doc.)
SRS (System Requirement Spec.)
HLD (High-Level Design)
LLD (Low-Level Design)



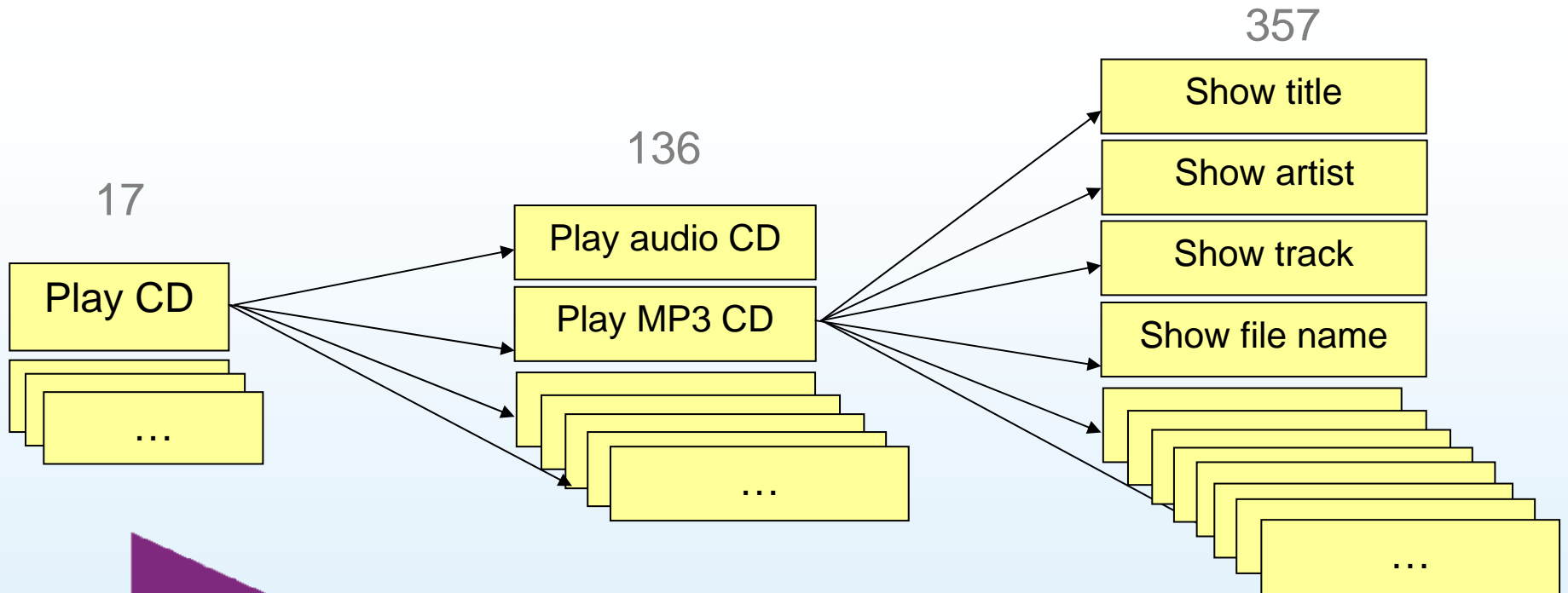
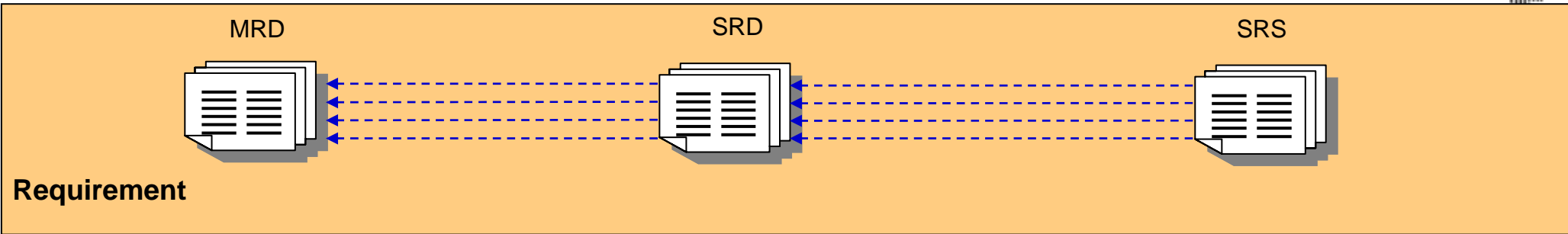
Test Overview



Example of Requirement Traceability



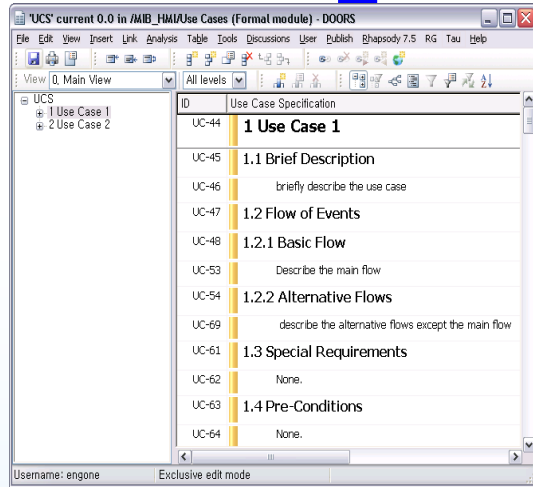
MRD (Marketing Requirement Doc.)
SRD (Solution Requirement Doc.)
SRS (System Requirement Spec.)



How to do MDD? 1/2

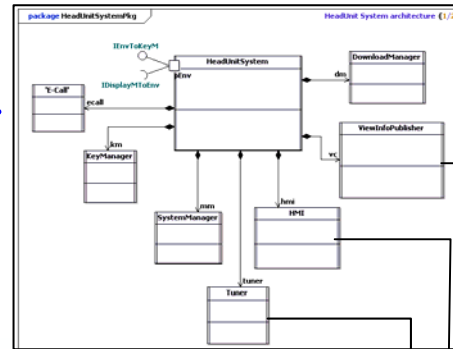


Requirements

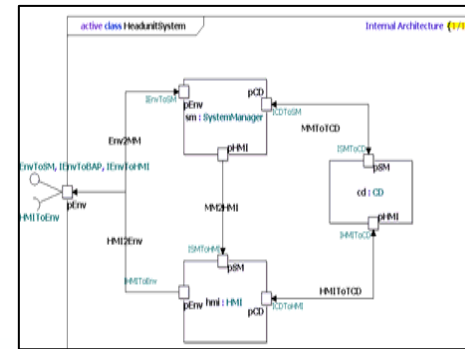


Requirements

Architecture

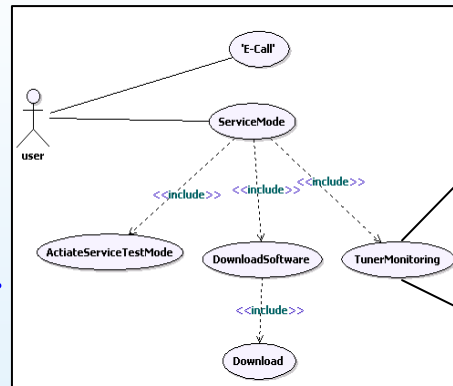


Static Structure

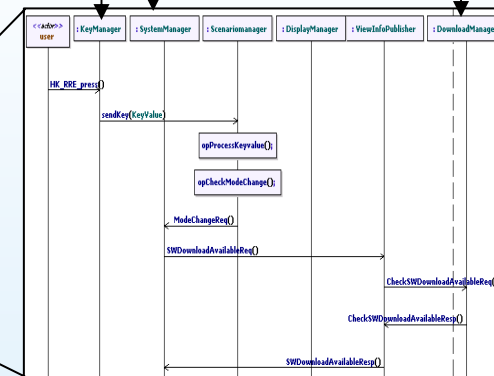


Internal Structure

Behavior



Functions of System

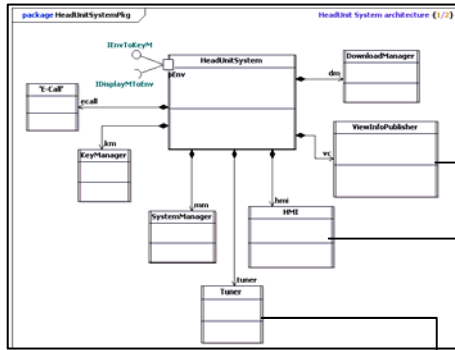


Behavior of Function

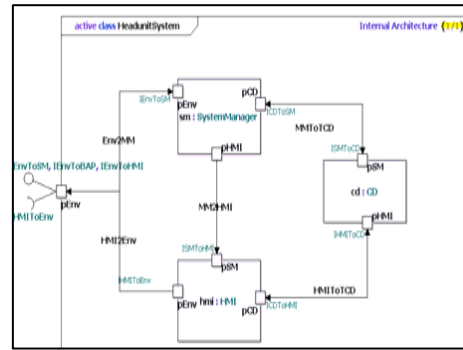
How to do MDD? 2/2



Architecture

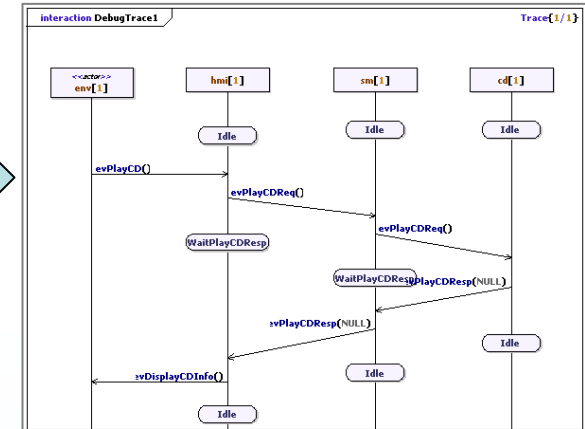


Static Structure

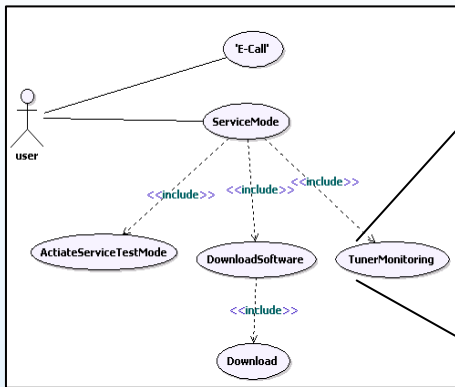


Internal Structure

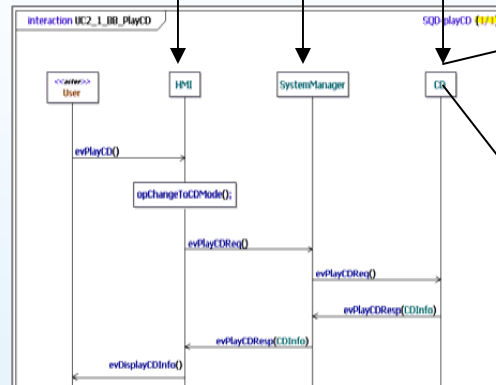
Model Verification



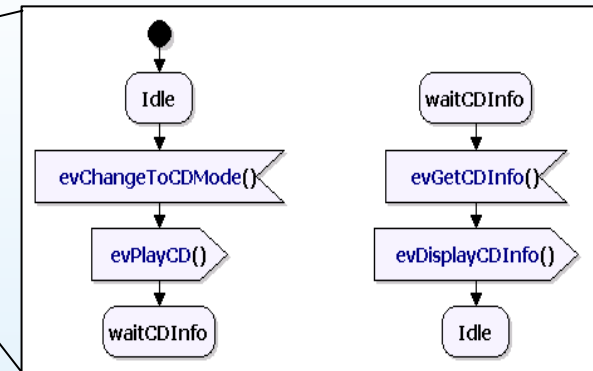
Behavior



Functions of System



Behavior of Function



Behavior of Class

Sample MDD Projects

- Car infotainment system





Marketing Requirement Doc. (MRD)

Requirement Management : DOORS

- LGE created a template for MRD from Project Architecture Workshop (PAW).



MRD (Marketing Requirement Document)



- MRD focuses on business use cases and stakeholder requirements.

The screenshot shows a software application window titled "MRD" current. The window has a menu bar with options: File, Edit, View, Insert, Link, Analysis, Table, Tools, Discussions, User, Publish, Tau, Help. Below the menu bar is a toolbar with various icons. The main area is divided into two panes. The left pane shows a tree view of the document structure, with "MRD" expanded to show sections 1 through 12. Section 5, "Product Overview", is expanded to show sub-sections 5.1 through 5.6. Section 5.2, "Business Use Cases", is selected and highlighted. The right pane shows a table of Marketing Requirement Document entries. The table has two columns: "ID" and "Marketing Requirement Document". The entries are as follows:

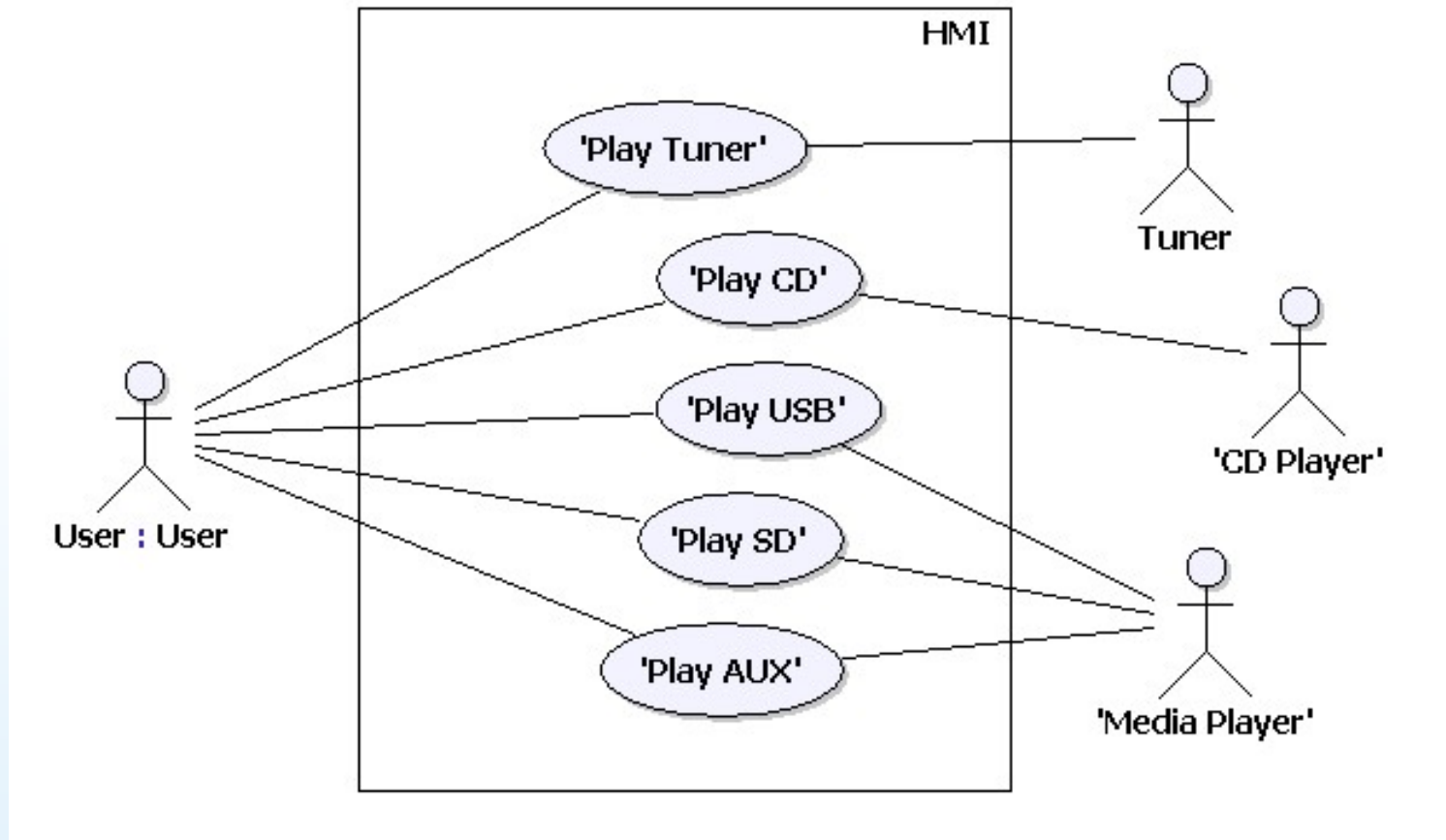
ID	Marketing Requirement Document
MRD-19	5.2 Business Use Cases
MRD-42	User shall be able to play Tuner.
MRD-43	User shall be able to play CD.
MRD-44	User shall be able to play USB.
MRD-45	User shall be able to play SD card.
MRD-46	User shall be able to make phone calls via Bluetooth.

At the bottom of the window, there is a status bar with the text "Username: jwjo" and "Read-only mode".

MRD Model: Business Use Cases



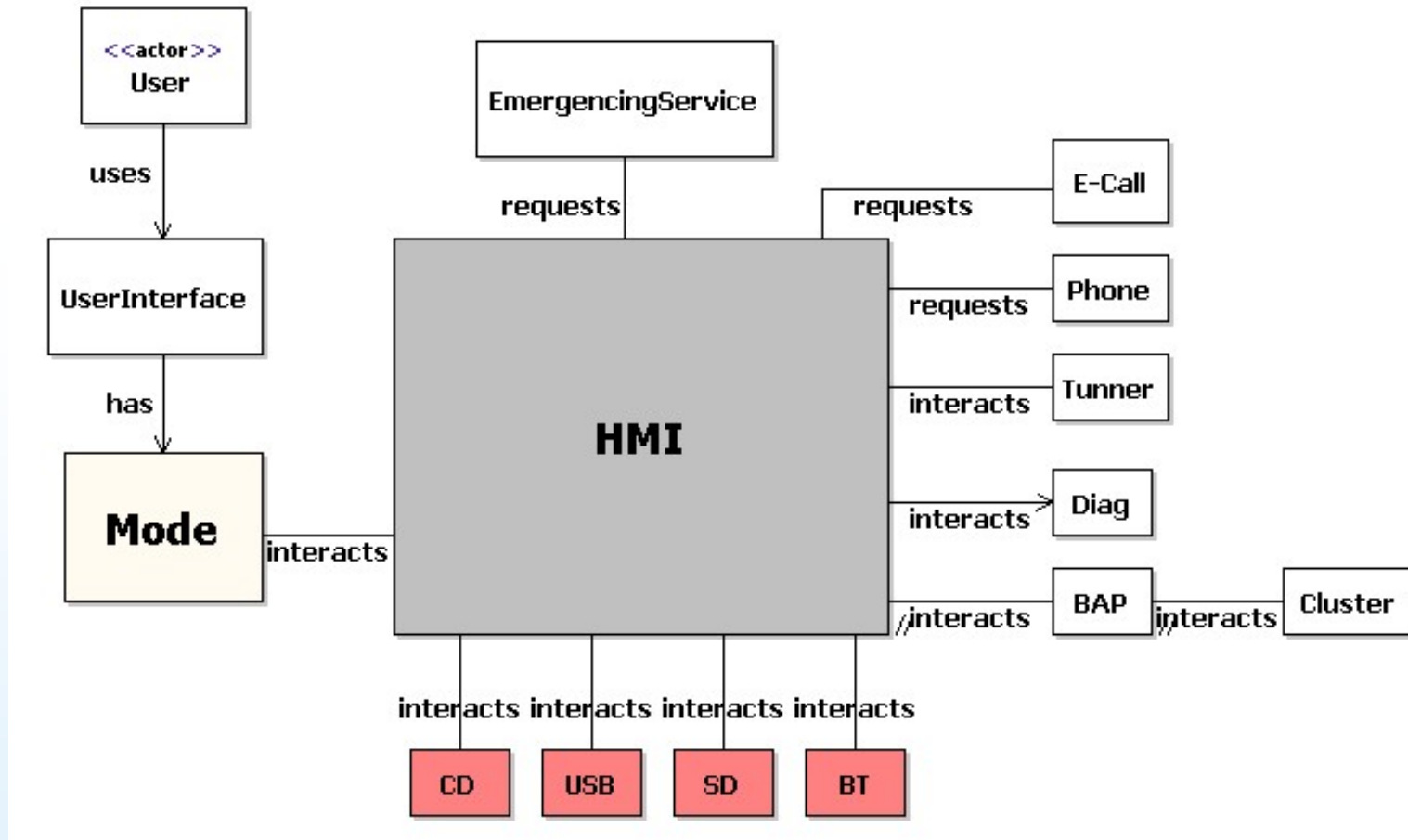
- Business use cases express what user would do with the system to accomplish user goals.



MRD Model: Conceptual Model



- Conceptual model shows initial thoughts about the whole system, HMI in this case.





Solution Requirement Document (SRD)

SRD (Solution Requirement Document)



- Requirements for the whole solution

The screenshot shows a software application window titled "SRD" current 1.0 (TT). The window has a menu bar with options: File, Edit, View, Insert, Link, Analysis, Table, Tools, Discussions, User, Publish, Tau, Help. Below the menu bar is a toolbar with various icons. The main area is divided into two panes. The left pane shows a hierarchical tree view of requirements:

- SRD
 - 1 Design Goal/Consideration/Feas
 - 2 Software Requirements
 - 2.1 Functional Requirements
 - 2.1.1 HMI Requirements
 - 2.1.2 HMI Entry Requirement
 - 2.1.3 CD
 - System shall be able to s
 - System shall be able to p
 - System shall be able to p
 - System shall be able to p
 - 2.2 NonFunctional Requirement
 - 2.3 Constraints
 - 3 Hardware Requirements
 - 4 Mechanical Requirements

The right pane displays a table of requirements with the following data:

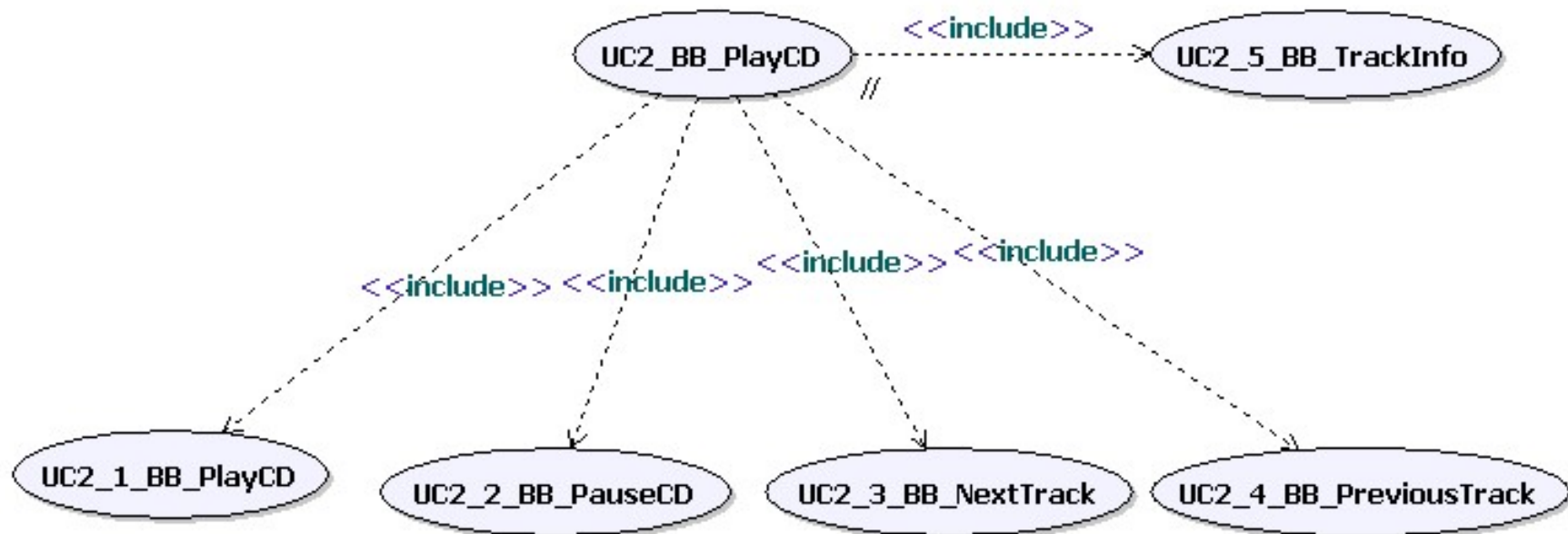
ID	Solution Requirement Document
SRD-289	2.1.3 CD
SRD-290	System shall be able to show play CD screen, which includes the following controls. <ul style="list-style-type: none">- play- pause- go to next track- go to previous track- get track information
SRD-291	System shall be able to play the last track automatically if available when media source changes to CD.
SRD-292	System shall be able to play CD_DAs.
SRD-	System shall be able to play compressed CDs.

At the bottom of the window, the status bar shows "Username: jwjo" and "Read-only mode".

SRD Model: Use Cases



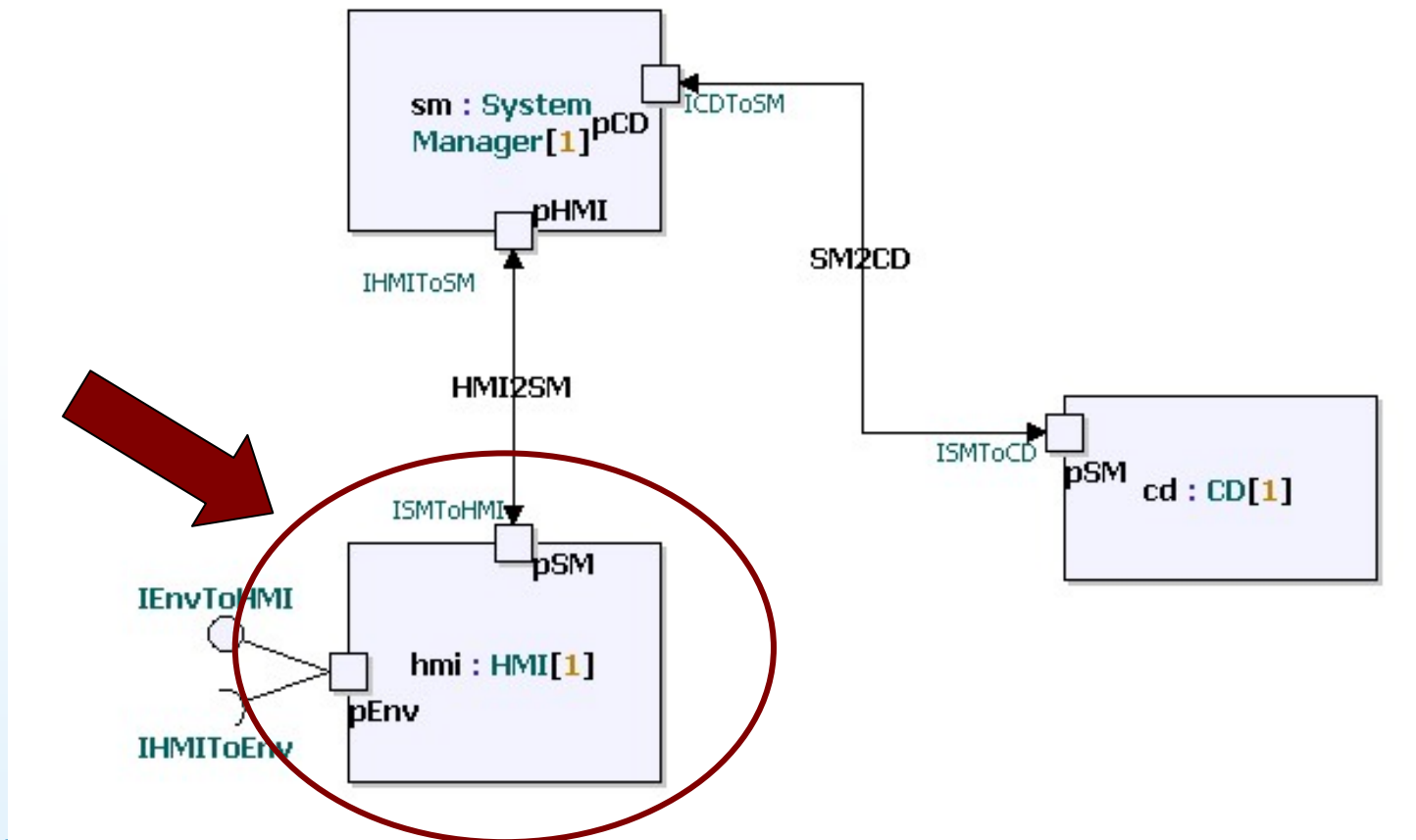
- Breakdown “Play CD” use case



SRD Model : Internal Structure of the Solution



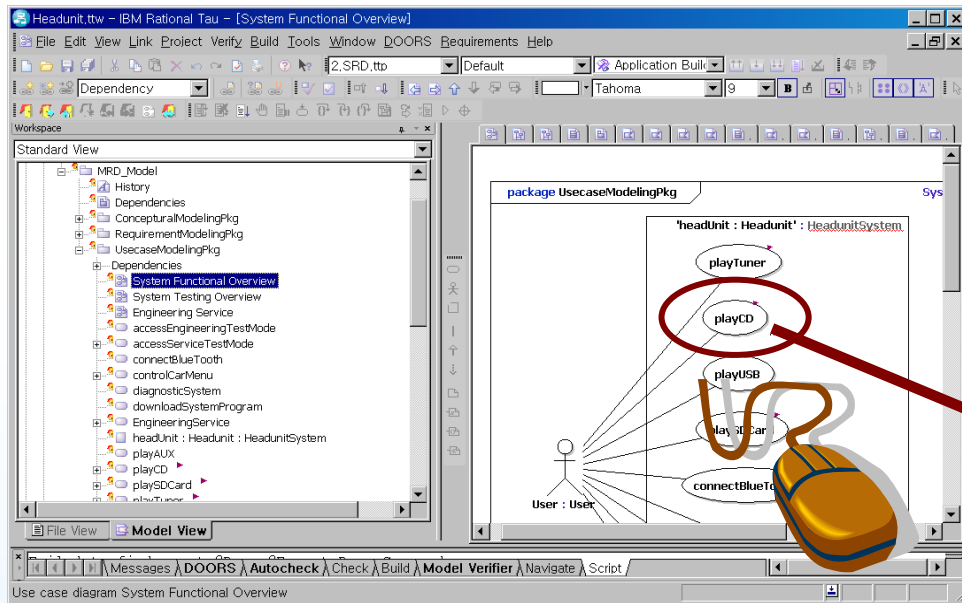
- Shows internal structure



Trace Model from Requirements: create links



- Create links directly from the modelling tool to requirement management tool

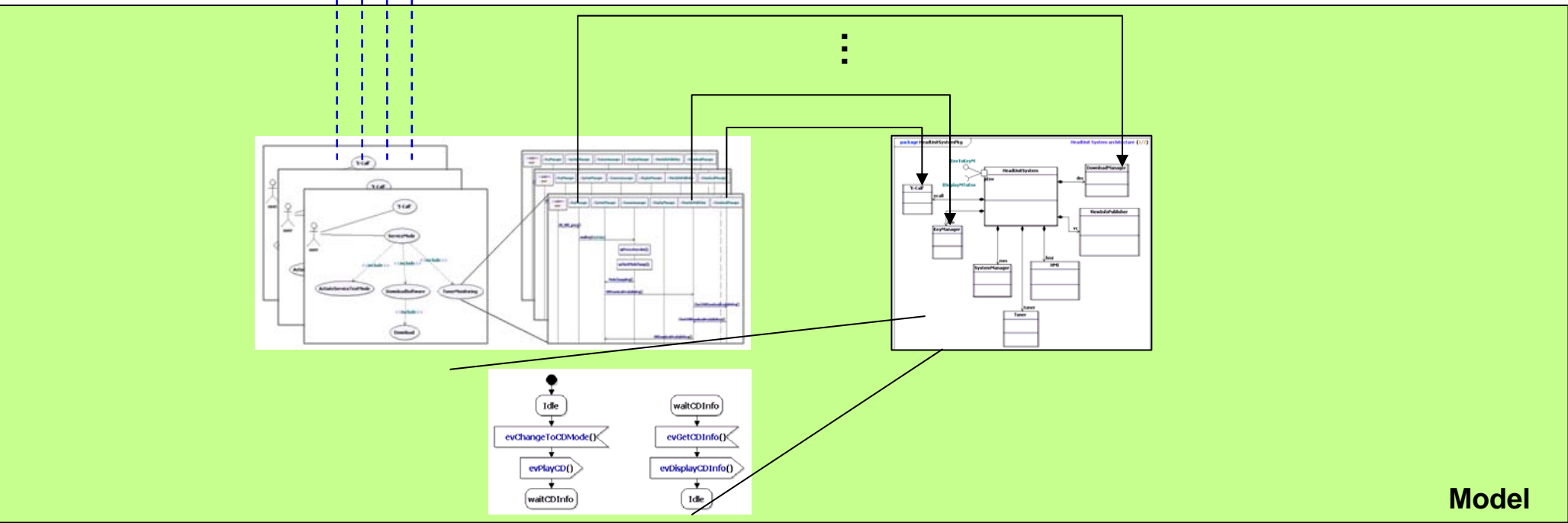


Model

Requirement

ID	Marketing Requirement Document
MRD- 19	5.2 Business Use Cases
MRD- 42	User shall be able to play Tuner.
MRD- 43	User shall be able to play CD.
MRD- 43	User shall be able to play USB.
MRD- 44	User shall be able to play SD card.
MRD- 45	User shall be able to make phone calls via Bluetooth.
MRD- 46	

Traceability of Requirement and Model at SRD





System Requirement Specification (SRS)

SRS (System Requirement Specification)



- Identify systems inside the whole solution

The screenshot shows a software application window titled "SRS" current 1.1. The window has a menu bar with options: File, Edit, View, Insert, Link, Analysis, Table, Tools, Discussions, User, Publish, Tau, Help. Below the menu bar is a toolbar with various icons. The main area is divided into two panes. The left pane shows a hierarchical tree view of the SRS structure. The right pane shows a table of requirements.

ID	System-Subsystem Requirement Specification	Comment
SRS-10	3.1.1 Display Manager	
SRS-119	Display manager shall be able to generate view based on the request from Scenario Manager.	
SRS-120	3.1.1.1 CD	
SRS-121	Display Manager shall provide play button in play CD screen that toggles to pause when user presses it.	
SRS-122	Display Manager shall provide pause button in play CD screen that toggles to play when user presses it.	
SRS-123	Display Manager shall provide next track button in play CD screen that jumps to the next track when user presses it.	
SRS-124	Display Manager shall provide previous track button in play CD screen that jumps to the previous track when user presses it.	

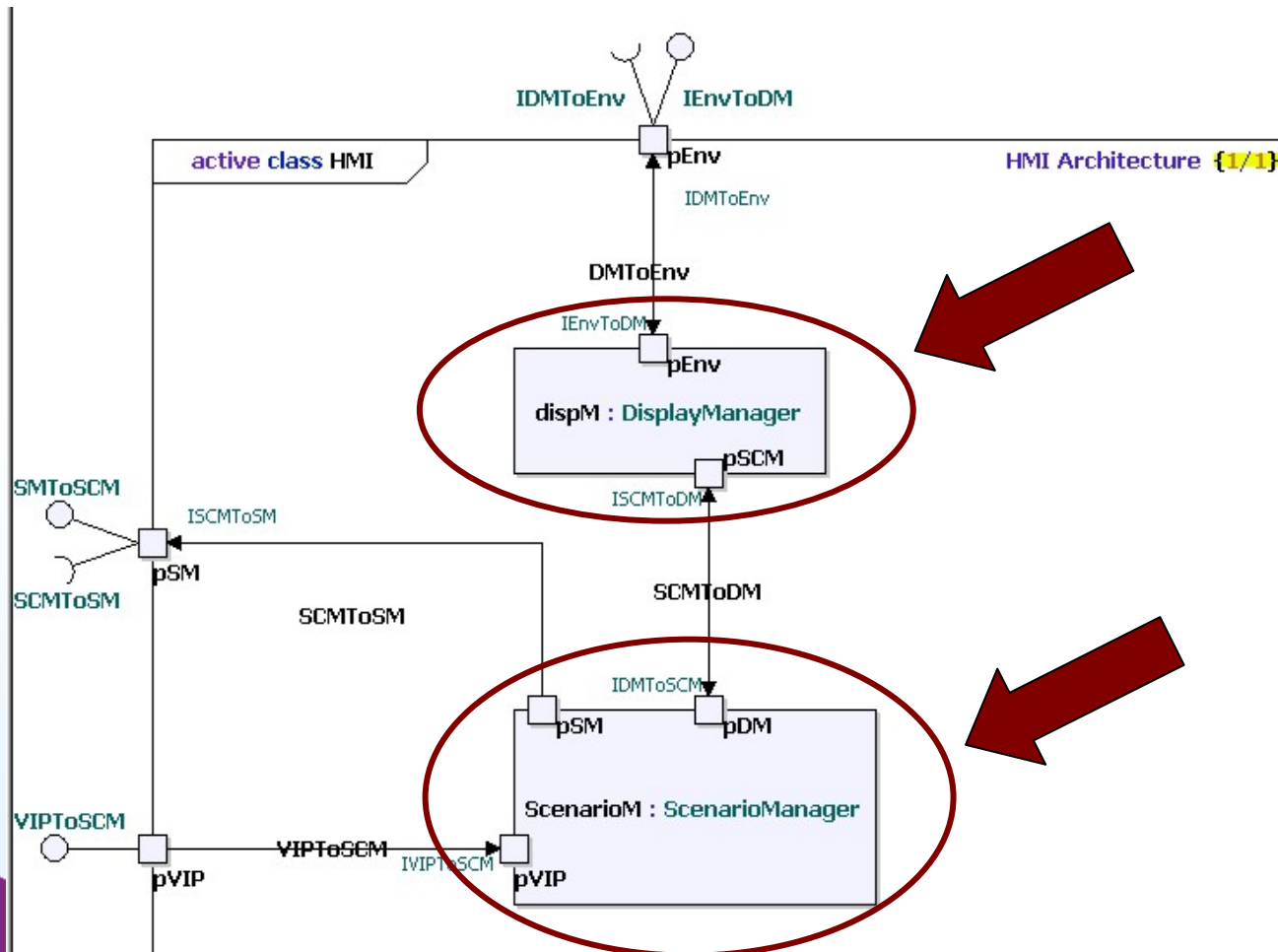
The table is highlighted with a red border. The left pane shows a tree view with the following structure:

- SRS
 - 1 INTRODUCTION
 - 2 SYSTEM OVERVIEW
 - 3 SYSTEM FEATURES
 - 3.1 HMI
 - 3.1.1 Display Manager
 - Display manager shall be a
 - 3.1.1.1 CD
 - Display Manager shall p
 - Display Manager shall p
 - Display Manager shall p
 - Display Manager shall p
 - Display Manager shall b
 - Display Manager shall b
 - Display Manager shall b
 - Display Manager shall b
 - Display Manager shall b
 - Display Manager shall b
 - 3.1.2 Scenario Manager
 - Scenario Manager shall be
 - Scenario Manager shall be
 - 3.1.2.1 CD
 - 3.1.2.2 Tuner
 - 3.2 System Manager
 - 3.3 Key Manager
 - 3.4 Touch Manager

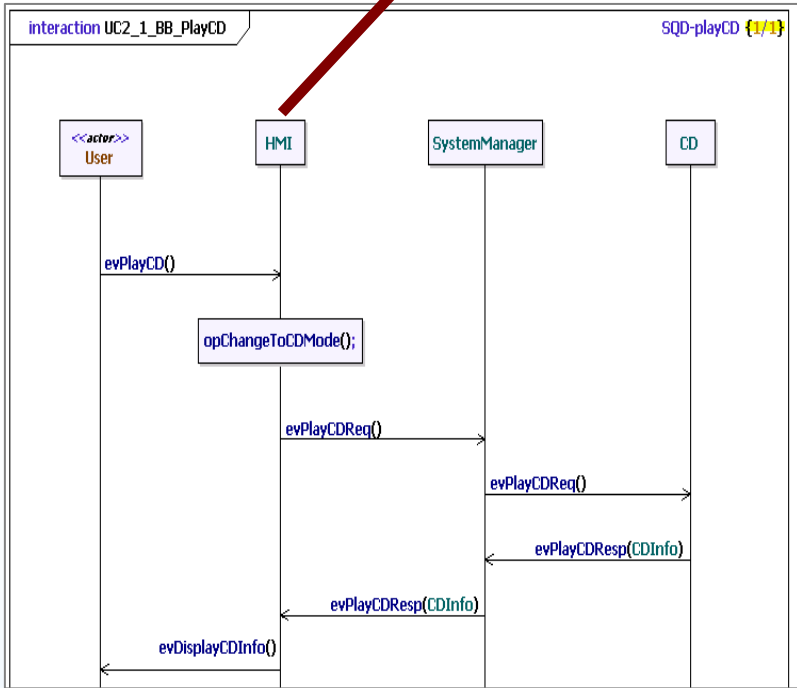
SRS Model : Internal Structure of HMI Subsystem



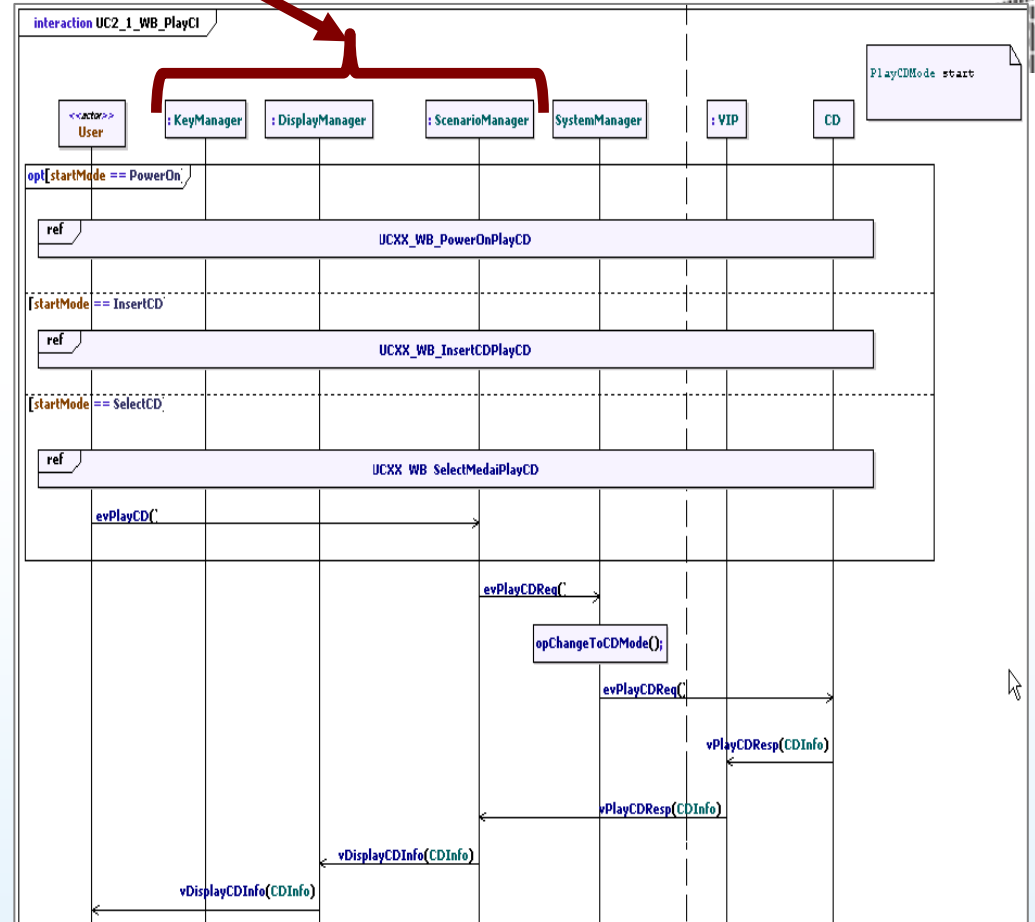
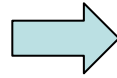
- Breakdown HMI into more detailed components, Display Manager and Scenario Manager



SRD to SRS

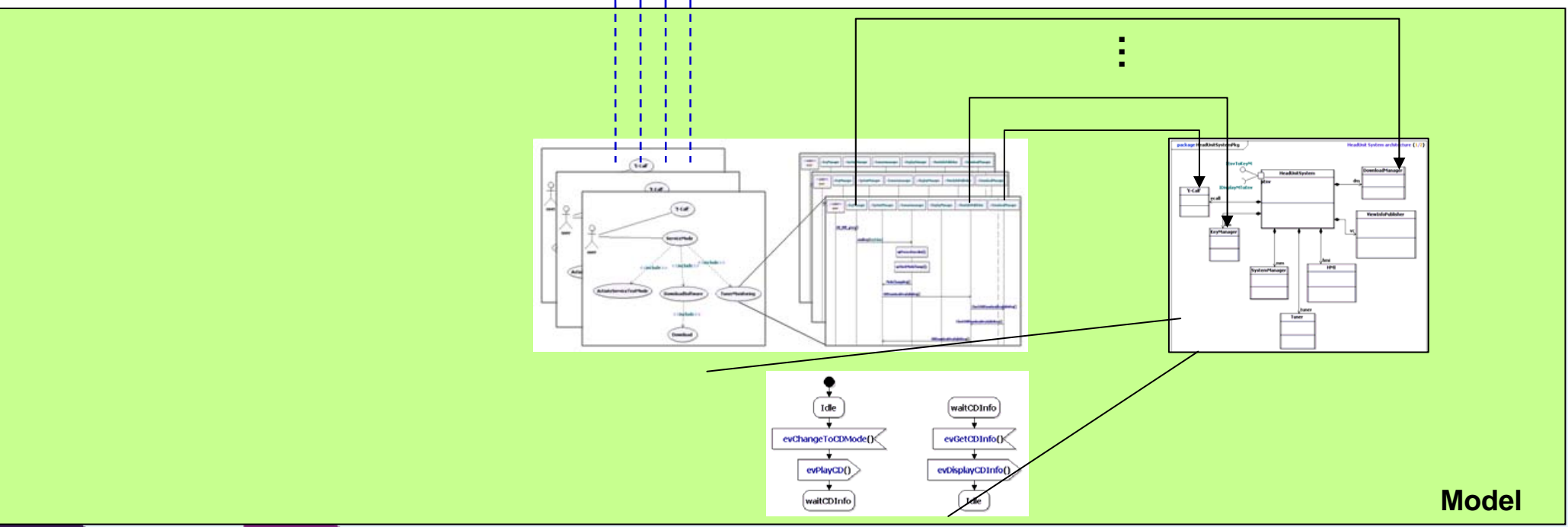
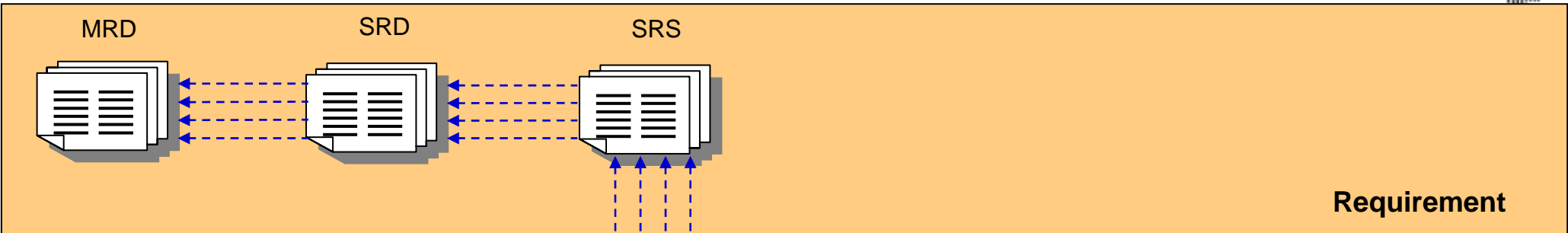


SRD : Sequence



SRS : Sequence

Traceability of Requirement and Model at SRS



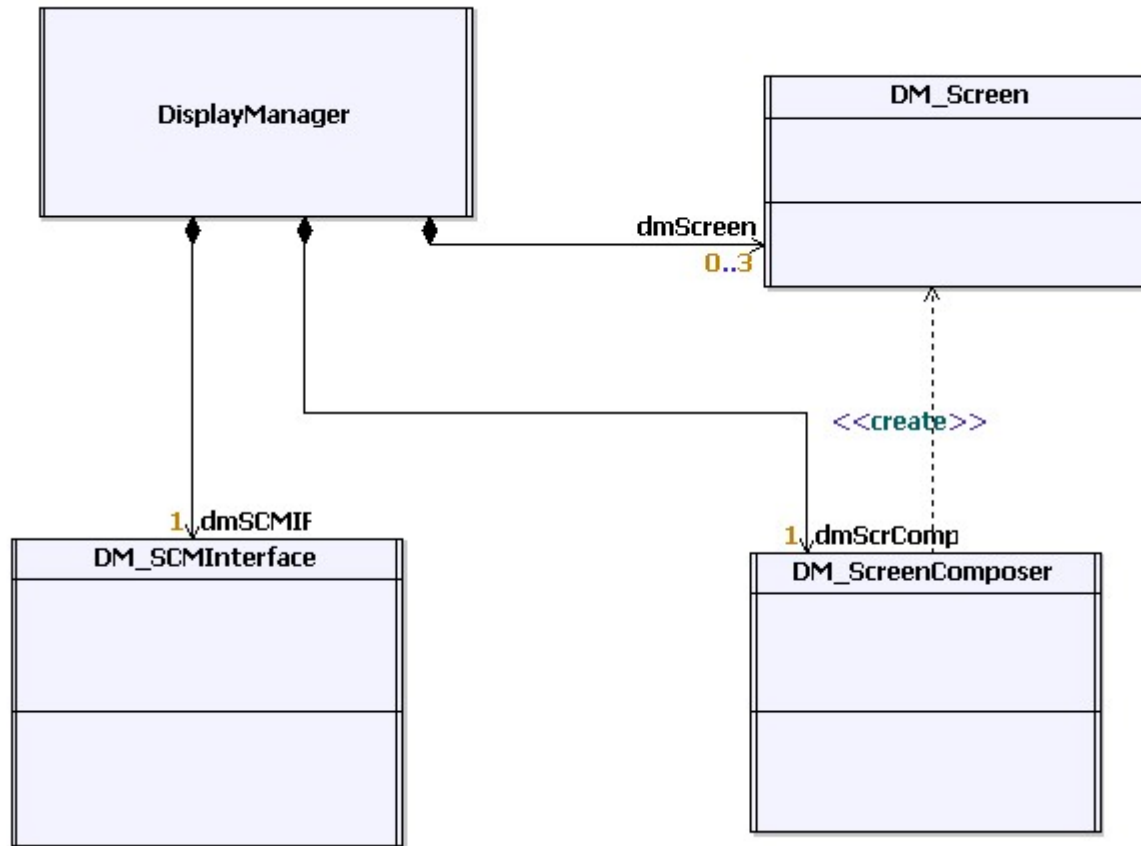


High Level Design (HLD)

HLD Model 1 : Display Manager



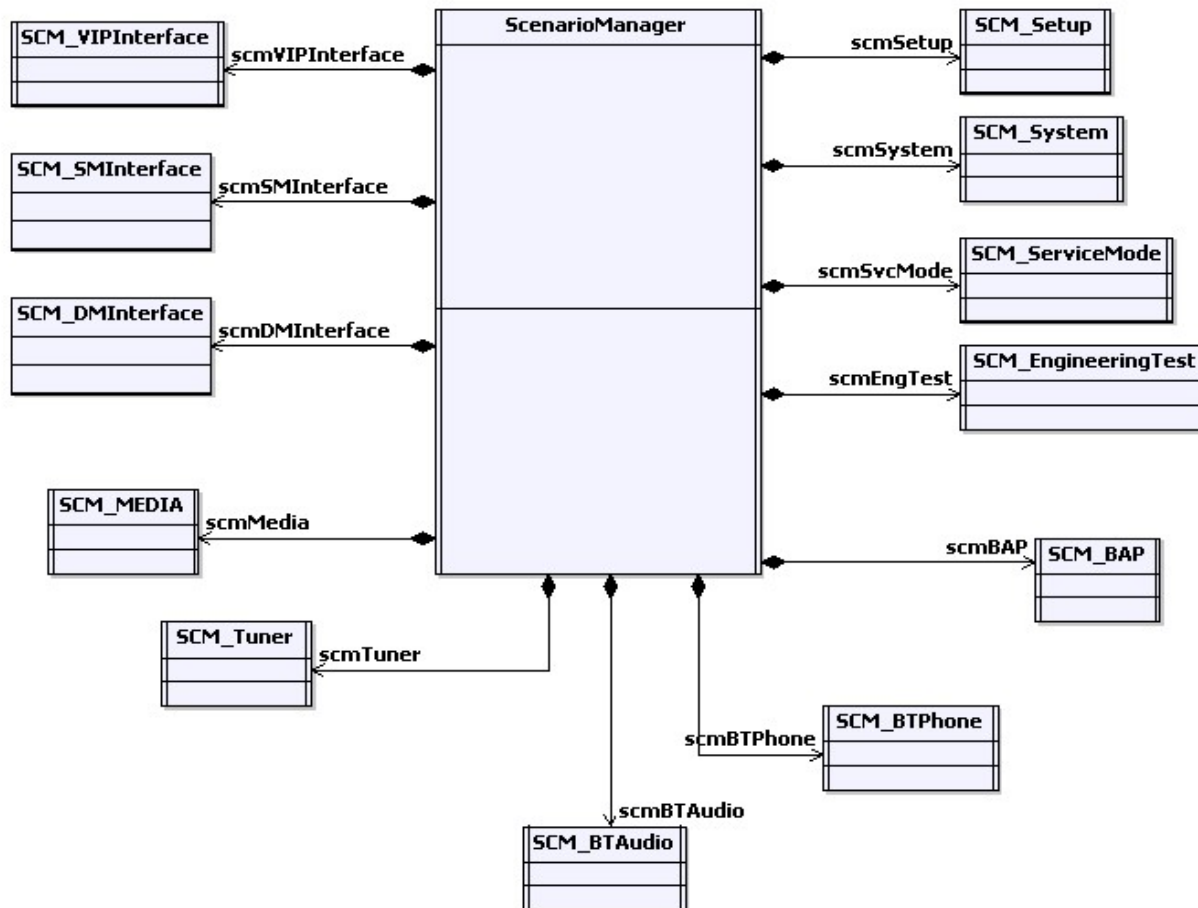
- Breakdown “Display Manager”



HLD Model 2 : Scenario Manager



- Breakdown “Scenario Manager”



HLD : Code Generation

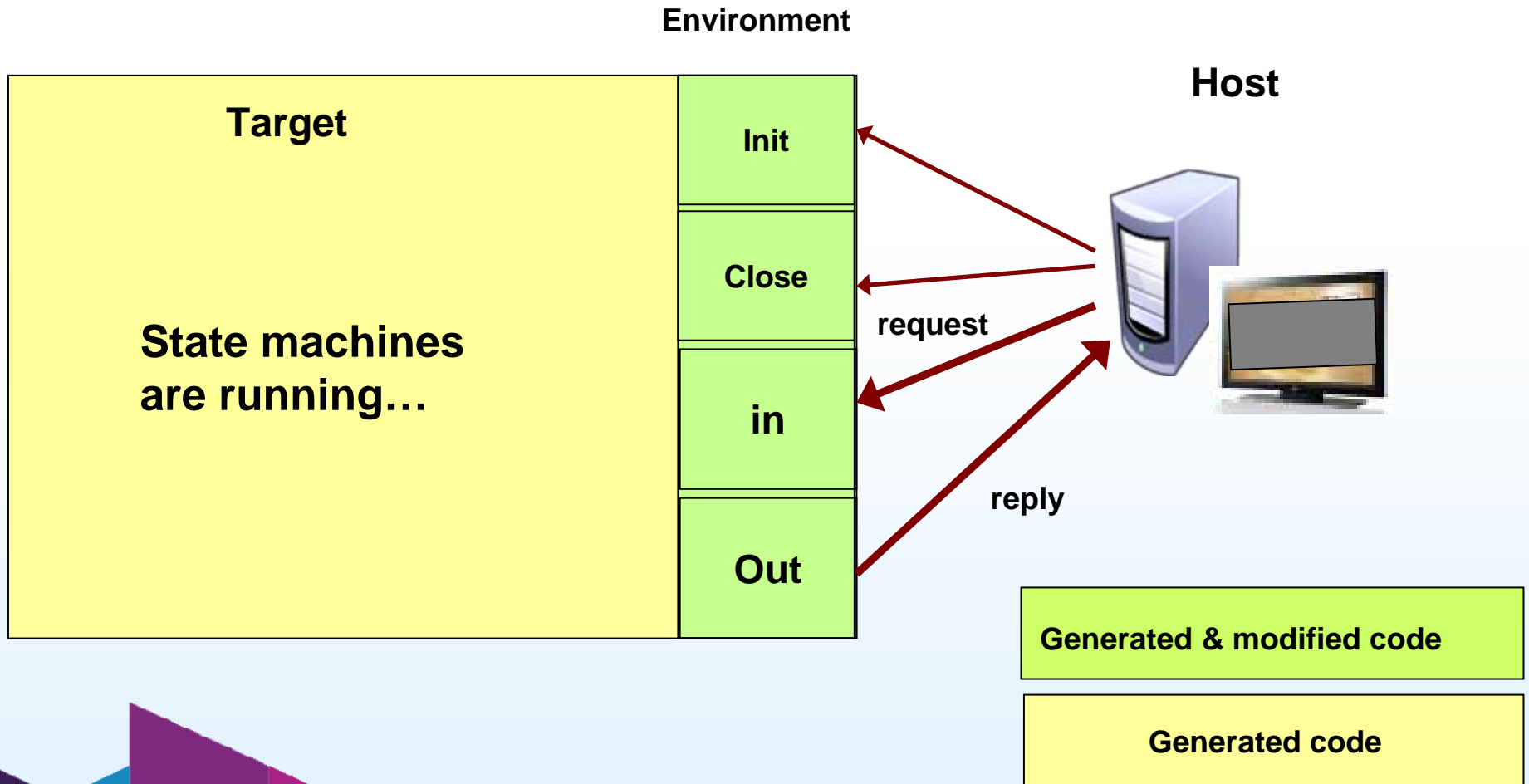


- Generated code from the modelling tool based on state machines, were already verified during simulations
- Had a choice to generate the following programming languages, and chose C
 - C
 - Agile C (small footprint)
 - C++
 - Java
 - C#

HLD : Demo Target Configuration



- ARM9 SoC running Automotive Grade Linux (AGL)





Conclusion

Pros of MDD Projects

- Able to manage requirements at different levels
 - MRD
 - SRD
 - SRS
- Able to collaborate
 - Used same language, UML
 - Reviewed system requirements & design at early stages
 - Able to use output as process document
 - Easily separated requirements for outsourced components
 - Able to identify non-functional requirements since the beginning



Cons of MDD Projects

- Took some learning curve to get familiar with different requirement levels and system design process
- Took time to learn how to use various new tools
- Configuration management could get tricky with projects for UML
- Needed change management process



Some Numbers

- MDD effort needed compared to previous developments
 - Requirement analysis: x2
 - Architecture design: x4
 - Implementation: x0.3
 - Verification: x0.5
- What do the above numbers mean?
 - Need more effort up front (requirement analysis & architecture design)
 - Actual development effort goes down (implementation & verification)






QUESTIONS

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