BOOK IB - INSULIN PUMP (MODULE B)





Feature Function Package Structures with the Executable MBSE Profile

14 JUNE 2024

OPEN LAB TUTORIAL

RHAPSODY V9.0.2

EXECUTABLE MBSE PROFILE V4.3.E.RELEASE

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- This lab book is one of two workshop lab books that build the insulin pump system project from scratch using the open-source Executable MBSE profile written by MBSE Training and Consulting Ltd
- It uses version 4.3.e.Release of the SysMLHelper: <u>http://www.executablembse.com/</u>
- The SysMLHelper is licensed under GPL 3.0 which is a copyleft license, meaning that any copy or modification of the original code must also be released under the GPL v3
- The SysMLHelper is entirely self-contained Java, a conscious decision was made not to use third-party or open-source libraries/.jars other than a standard Java runtime (incl. Swing for GUI) and the Rhapsody Java API .jar
- It may take to 1-2 hours to complete this lab book, assuming everything is correctly installed

AUTO-CREATE USE CASE PACKAGE STRUCTURE LAB IB1

"INSULIN PUMP" CASE STUDY

LAB IB1

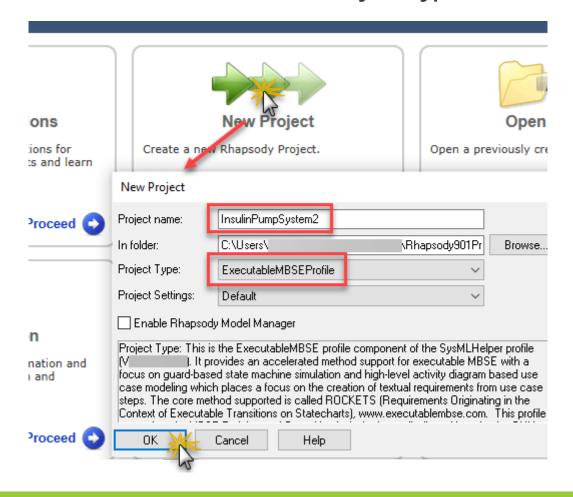
"hear and I forget. I see and I remember. I do and I understand" (Confucius 551 BC - 479 BC)



- This lab is the same as lab IA4 in previous lab book. If you have done it already then you can skip to next lab.
- There are typically 3 options to perform functional modeling with SysML:
 - Use of operations, owned by blocks (in Rhapsody there are some executable methods that work well with sequence and state machine diagrams)
 - Use of activities and activity diagrams (a classic SysML methods)
 - Use of function blocks (a novel approach possible by extending SysML)
- In this lab we show the function blocks method that makes use of block definition diagrams and internal block diagrams. The following element types are introduced.
 - Function Block: A type of block that represents behavioral feature of a subsystem
 - Feature Block: A type of function block that represents a behavioral feature of a system, exposed on the boundary of the system (user perceivable)
 - Feature Function package: A container for feature and function blocks

- Use of Feature and Function Blocks is a novel approach but does solve some intrinsic issues with both SysML and Rhapsody. It:
 - Enables same diagrams to be used for both structural and functional decomposition, i.e., collapses number of notations to two SysML diagrams, bdd and ibd
 - Enables use of composition to perform allocation, making it easy to allocate same function to different elements of definition
 - The complexity of keeping action pins and activity parameters in sync is considered less work with ports. By using blocks, we can make use of ports for defining interfaces required, provided, or exchanges in/out
 - As blocks are central to SysML, the usability features/display properties of blocks/parts are more powerful than the matching activity diagram counterpart in Rhapsody.

 Create a New Project called InsulinPumpSystem2 in a Read/Write folder using the ExecutableMBSEProfile as the Project Type



View the Log window & Ensure the profile loaded

```
SysMLHelperPlugin is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even New right-click 'MBSE Method' commands have been added.

Info : ExecutableMBSE_RPApplicationListener was loaded - Listening for events (double-click etc)

Info : The ExecutableMBSE profile version is

Info : The project called InsulinPumpSystem does not have the ProfileDate and ProfileVersion tags set Your installed ExecutableMBSE profile version is

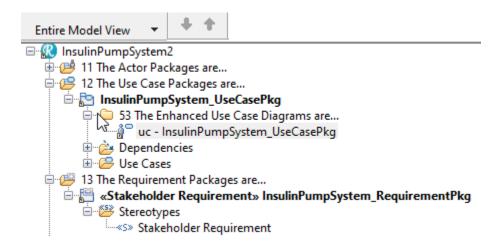
It is recommended to right-click and run the Profile's Setup project properties command to update the project to the latest profile before proceeding

Check Model \( \) Build \( \) Configuration Management \( \) Animation \( \)
```



The ExecutableMBSE profile includes a Java plugin that adds new menus to assist with method automation. The Log window contains an indication that this plugin has loaded plus which version it is. If you don't see this, then it's probable your \$OMROOT/Profiles/SysMLProfile folder is not in the correct location! This must be fixed before proceeding

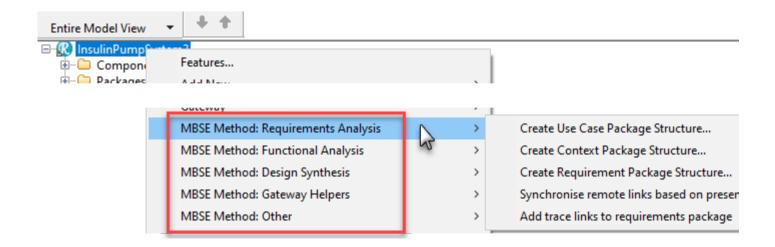
 The packages are automatically created including the dependency from the use case package to the requirements package



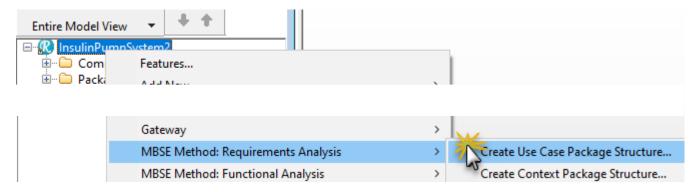
Click the Stakeholder Requirement stereotype and rename it to User Need



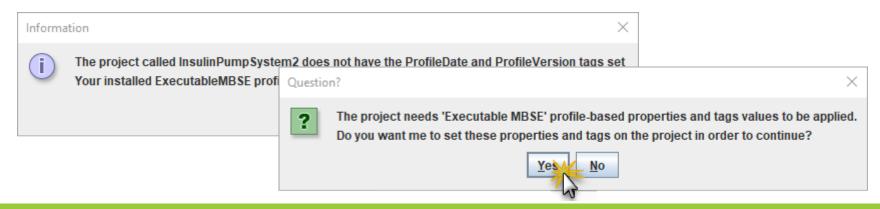
Right-click the project and view the context menu. Down the bottom of this
are menus added by the Executable MBSE profile hep file that begin with
MBSE Method: <Group Name>



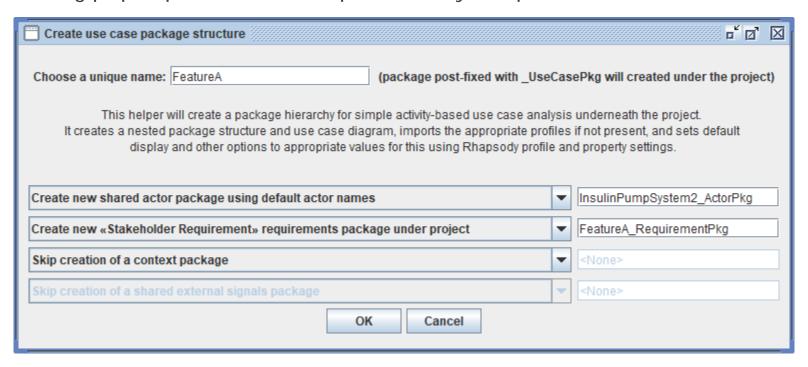
- The most common method to start a project with is MBSE Method: Requirements Analysis > Create Use Case Package Structure...
- Try this now



Click OK to proceed and Yes to setup the project properties



A dialog pops up that has been provided by the profile



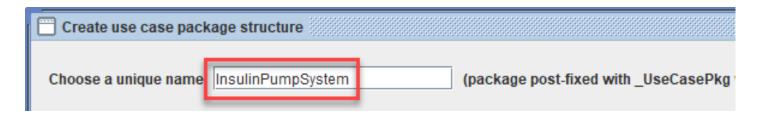


The options here are setup to create a use case package, requirement package and actor package at the same time

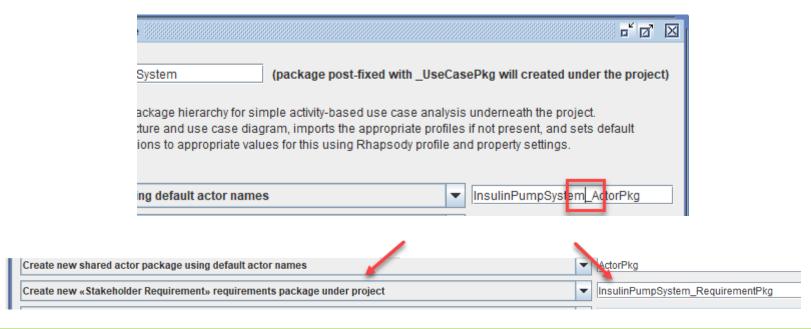
Choose the unique name InsulinPumpSystem

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Choose the unique name InsulinPumpSystem

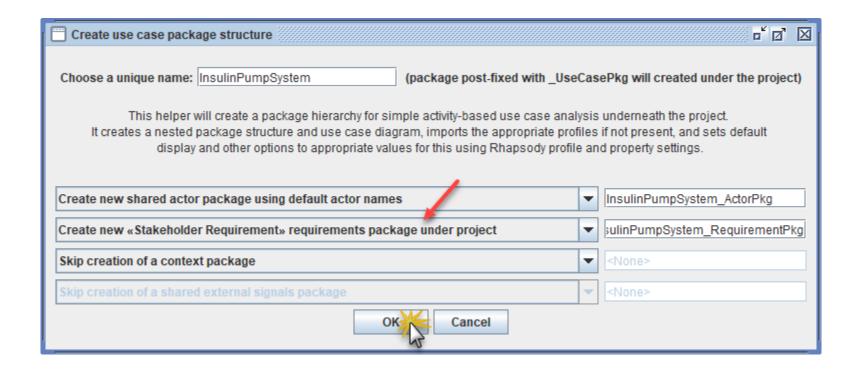


Remove the 2 from the Actor package name:

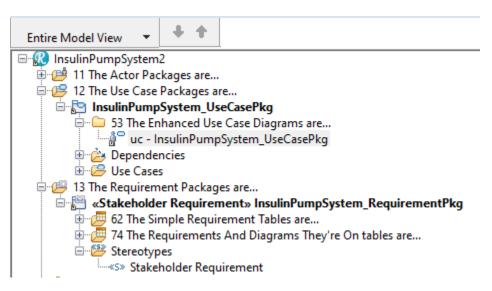


Check settings and click OK

- The option to create a stereotyped requirements package has been selected by default. Check the settings below
- Click OK to create the model



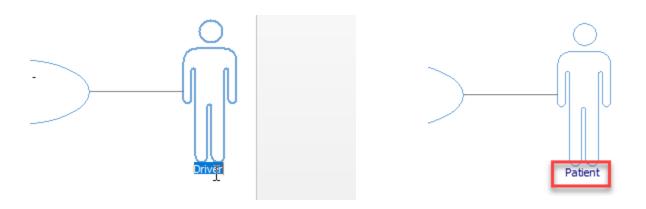
 The packages are automatically created including the dependency from the use case package to the requirements package



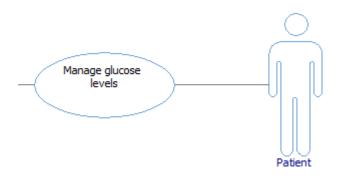
Click the Stakeholder Requirement stereotype and rename it to User Need



Double-click the Driver actor's name and change it to Patient



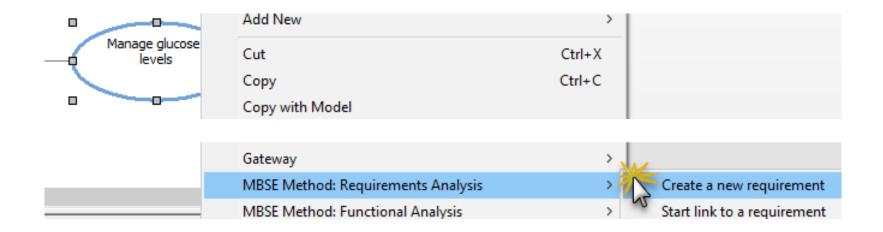
• Single-click the text to rename the use case to: Manage glucose levels



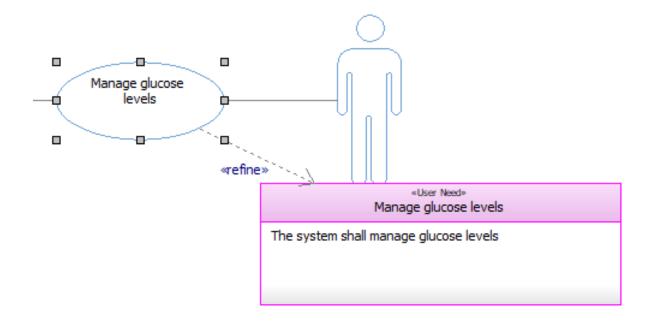


Double-click functionality is overridden on a use case. If a dialog pops up asking to create an activity diagram, then click No.

- A simple helper can be used to create a requirement and associated traceability at the same time
- Right-click Manage glucose levels and choose MBSE Method: Requirements
 Analysis > Create a new requirement



 The helper has created the requirement, established a refinement relationship to it, and populated the requirement on the diagram. Some initial text has been added based on the source element

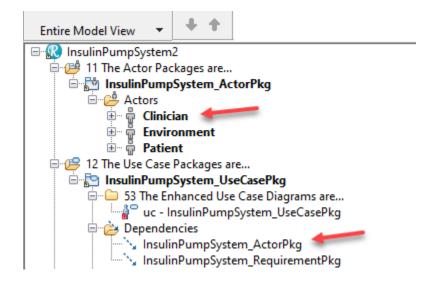


 Add the Inform clinical decisions use case and Clinician actor to finish the diagram below

uc [12 Use Case Package] InsulinPumpSystem_UseCasePkg [uc - InsulinPumpSystem_UseCasePkg] Draw use cases and «User Need» Manage glucose levels actors. The system shall manage glucose levels 1. A use case is a set of sequences of actions, including variants, that yield an observable result of value to an actor. **Insulin Pump System** «refine» Use case diagrams provide a high level Manage glucose levels context view of use cases and how they relate to actor(s). 3. You need to choose Environment Patient your system boundary/context to draw Inform clinical this diagram. Actors are decisions outside the system under design. 4. Consider running a use case workshop to create Clinician this: i.e. use this for «User Need» requirement elicitation Inform clinical decisions and as an opportunity to The system shall inform clinical decisions get stakeholder buy-in. Use cases contain.

sunny and rainy day

The Clinician actor was automatically moved into the Actor package. This
was done by the Profile's listener due to a dependency from the use case
package to the actor package





It was much quicker it was to create a consistent model structure using the helper. You can get straight into use case and requirement analysis

CREATE A FEATURE FUNCTION PACKAGE LAB IB2

"INSULIN PUMP" CASE STUDY

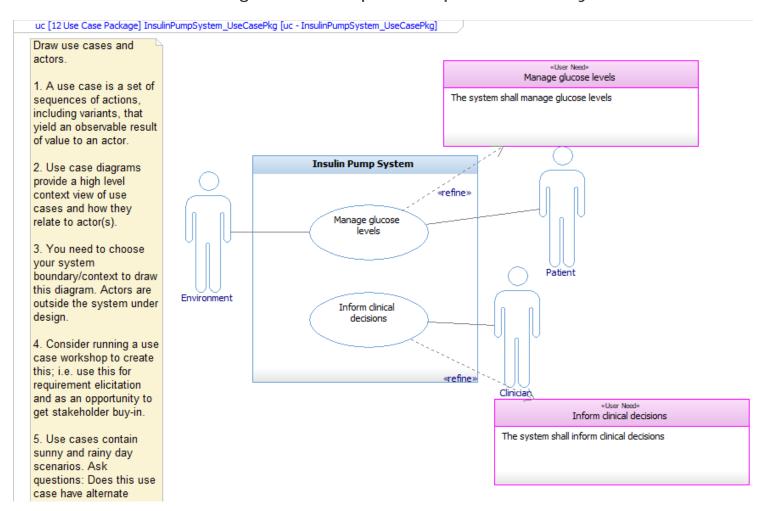
LAB IB2

"hear and I forget. I see and I remember. I do and I understand" (Confucius 551 BC - 479 BC)



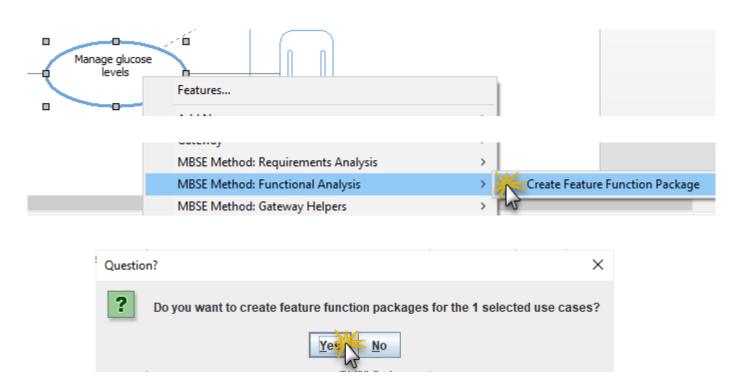
- Requirements are fantastic things to have in a model, because they can be linked to any model element. They provide a link outside the model into other worlds such as a requirements management tool
- They are limited as a model element hence we may choose to link the requirement to a model element that represents it instead. For example, an operation or a block
- The profile allows for both possibilities. However, in this example we will
 focus on use of specialized blocks to represent behaviours that we want our
 system or subsystems to do. By representing a function as a block, we can
 interweave them with blocks that represent structural elements on bdds and
 ibds
- A special type of package called a Feature Function Package is introduced to perform functional analysis (the identification of functions) using function blocks owned by a feature

Locate the use case diagram and open it up if necessary

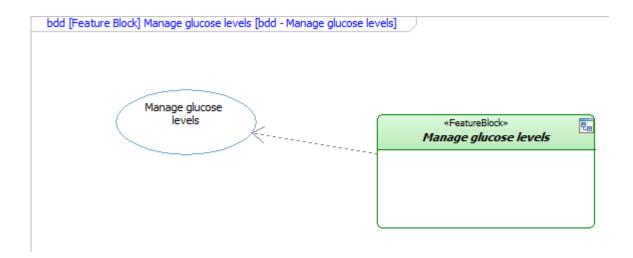


- In this lab we explore the use of function blocks and function usages to describe use case behavior.
 - Function Block: A specialisation of a Block introduced by the Executable MBSE profile to describe behavior rather than structure
 - Function Usage: A specialisation of a Part introduced by the Executable MBSE profile to represent use of a Function Block. These are created under the structural block (such as a Subsystem Block) or a behavioral block (such as a Feature Block) that owns the behavior
 - Feature Block: A specialisation of a Block introduced by the Executable MBSE profile that describes a top-level system function (one visible to actors on the system boundary)
- Features and Functions are kept in a separate part of the model to enable functional decomposition to be performed without touching the use case packages. This means that the two activities can be performed independently by different people

- Although it's possible to hand build, we can use a helper create a Feature Function Package for a Feature that represents a Use Case
- Locate the Manage glucose levels use case and choose MBSE Method:
 Functional Analysis > Create Feature Function Package



 A Feature Block with the same name as the use case is created. This can be thought of as a system-level function. It may have a one-to-one correspondence to the use case, although many-to-one or using them without Use Case diagrams is possible





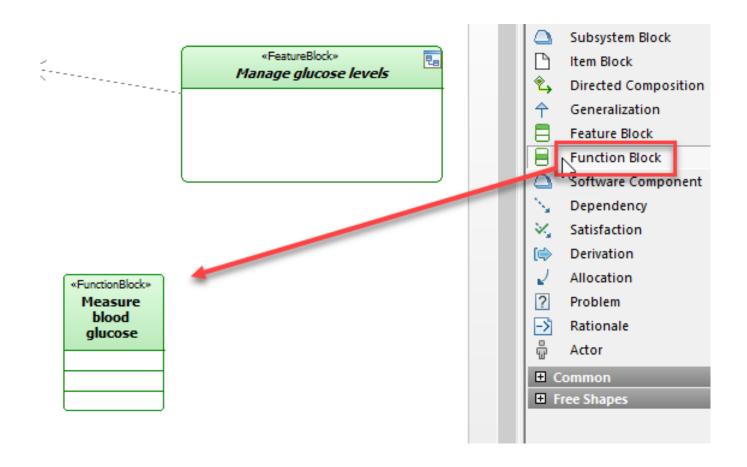
To show the Feature represents the behaviour of a use case, a dependency is established. The dependency is from the Feature to the use case (which may be in a read-only part of the model). No stereotype is applied so it is easier to draw

- The diagram that is opened is known as a block definition diagram (bdd)
- Blocks are elements of definition. They represent types of things that may exist, rather than their usage, hence the diagram is called block definition diagram
- We can use a bdd is to describe a hierarchical breakdown structure by establishing a **Directed Composition** relation between blocks. The level of behavior below the feature block will be modeling by breaking down the feature into a set of function blocks

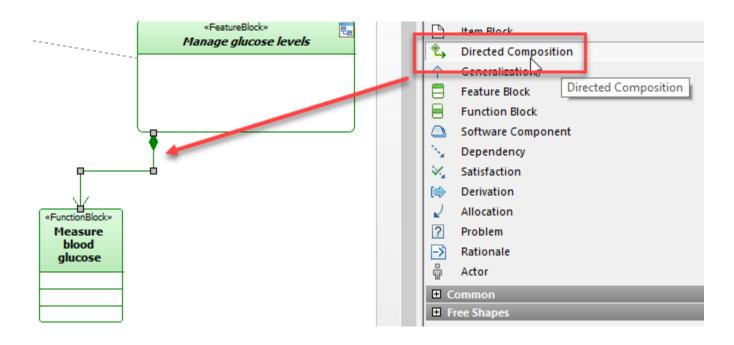
Add a Function Block: Measure blood glucose

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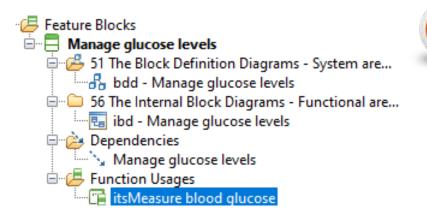
Add a Function Block called Measure blood glucose below the feature



 Draw a Directed Composition from Manage glucose levels feature to Measure blood glucose function

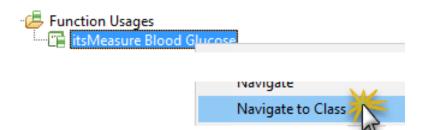


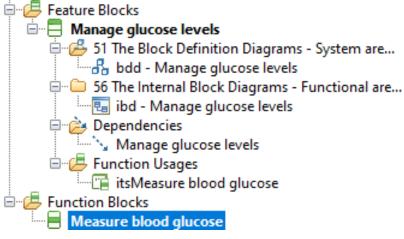
 Select the Directed Composition on the diagram and choose Navigate > Locate in browser The Function Usage (aka Part) is created underneath the owning feature block



The same function to be reused in many different contexts. The element that defines the properties is the function block. A function usage is the use of the behavior properties defined by the function block

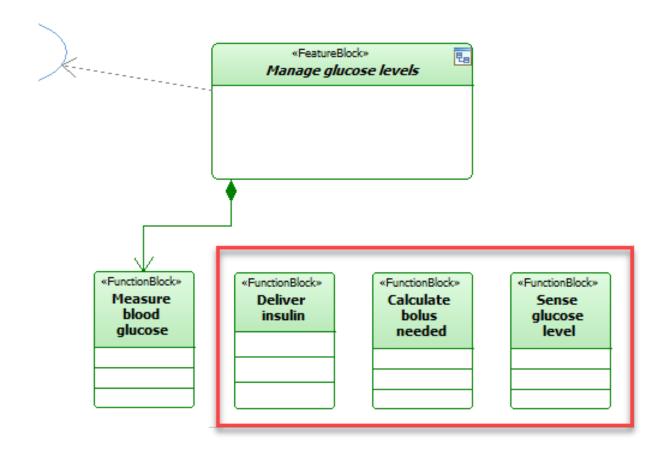
 Right-click the function usage to Navigate to Class



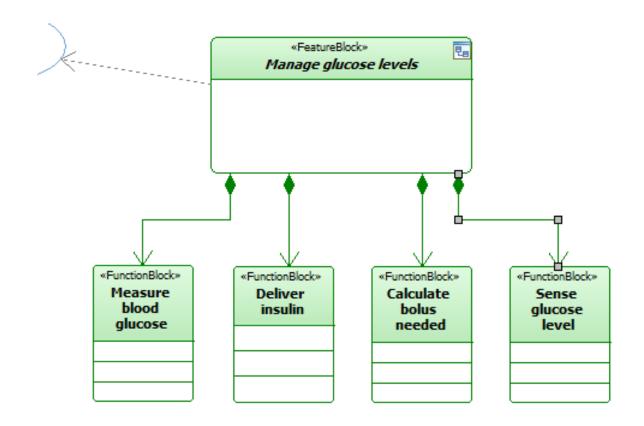


Complete the diagram

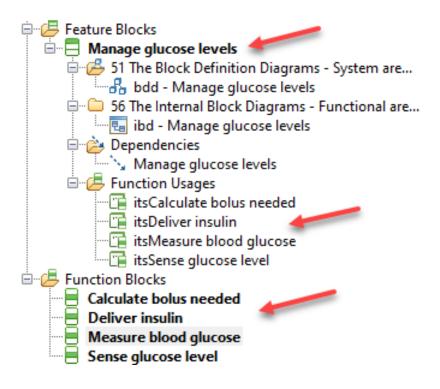
Add three model function blocks: Deliver insulin, Calculate bolus needed,
 Sense glucose level



 Draw Directed Compositions to complete the diagram and create the associated function usages underneath the feature



 Expand the browser. The Feature Block has nested Function Usages, and the package contains the Function Blocks (which are the blocks - units of definition that detail their requirements, properties and ports)



FUNCTION CHAINS WITH IBDS LAB IB3

"INSULIN PUMP" CASE STUDY

LAB IB3

"hear and I forget. I see and I remember. I do and I understand" (Confucius 551 BC - 479 BC)

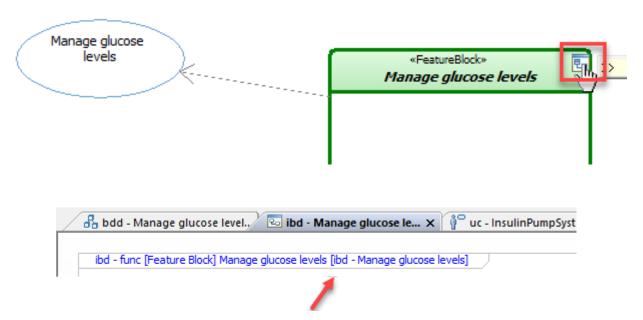


Using Internal Block Diagrams

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- Using convention SysML methodologies we might model functional flow using SysML activities and activity diagrams
- The Functional Method supported by the Executable MBSE profile instead allows the behavioural aspects of how Function Usages are chained together to be described using Internal Block Diagrams. This can be done in either:
 - A behavioural context, irrespective of the allocation of behavior to subsystems
 - A structural context, where the subsystem boundaries are present
- The key benefit of using function blocks is that it allows a closely relationship between behavior and structural aspects of the system, something not easy to achieve with separate structure and behavior diagrams (something that the Arcadia/Capella method is better at than SysML).

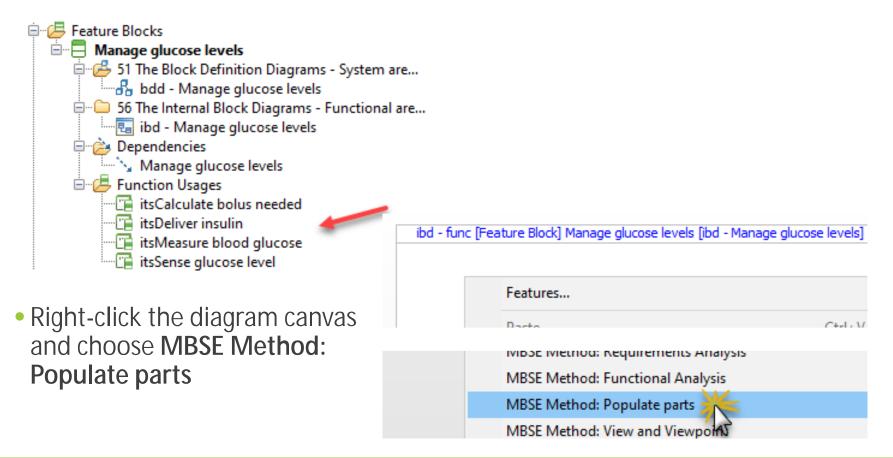
An internal block diagram was created automatically for the Feature Block.
 Navigate to it by clicking on the quick navigation icon in top-right of the graphical node





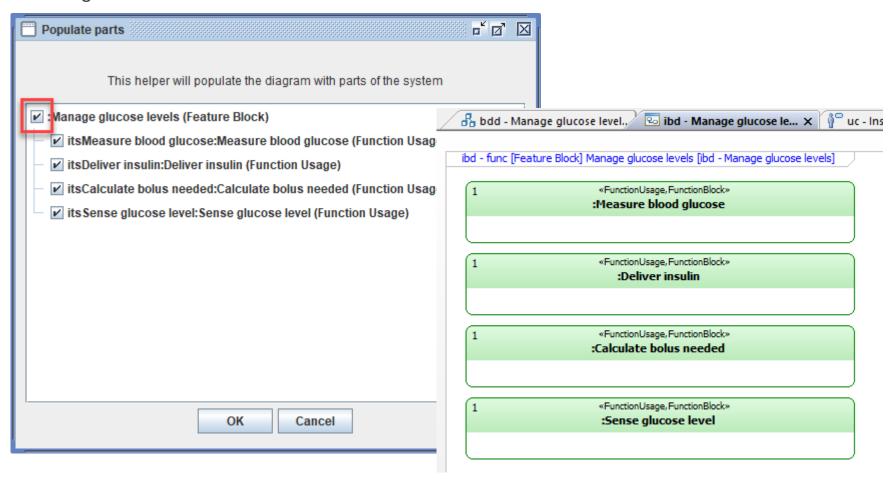
When using the methods supported by the profile, diagrams are always named with a prefix which is the SysML diagram type. This makes it easier to identify in the diagram tabs and pull-down lists

 An internal block diagram is a diagram of usages (aka parts) rather than blocks. We already have created these using directed compositions on the bdd. We can populate these using a helper provided by the profile



Select usages and click ok

 Check the box to select all the usages and click OK to populate on the diagram



Reorder and resize the function usages on the ibd

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Reorder and size the function usages like the below





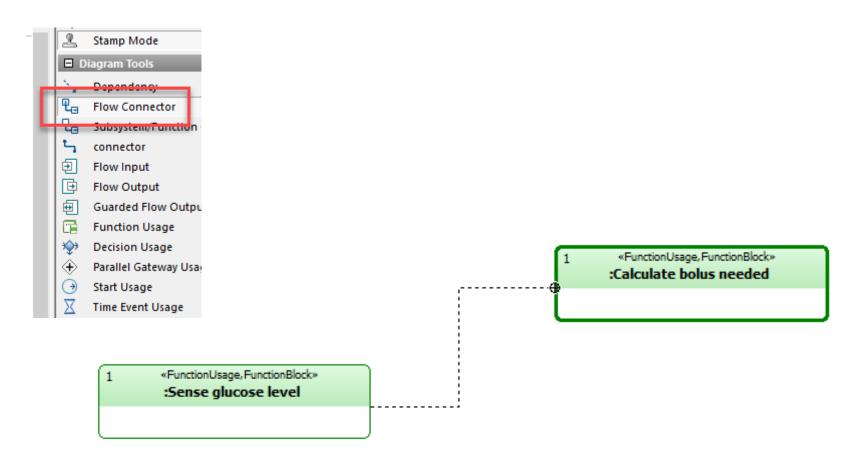


The layout toolbar can prove handy. Holding down Ctrl key can be used to multi-selected items

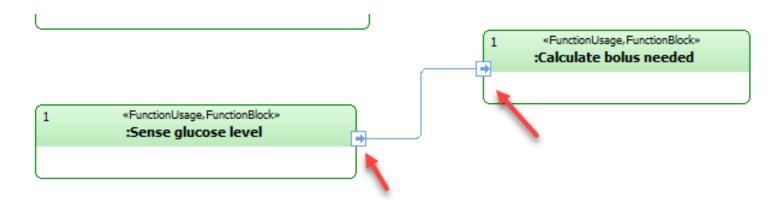
Reorder and resize the function usages on the ibd

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 Add a Flow Connector from Sense glucose level to the Calculate bolus needed function usage



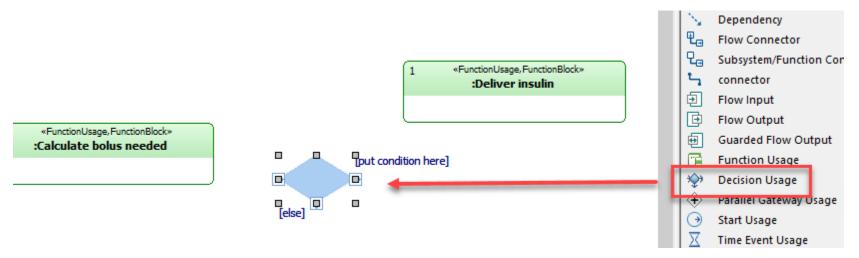
• The helper automatically creates flow ports with directionality on the boundary of the function usage (these are properties of the function block)



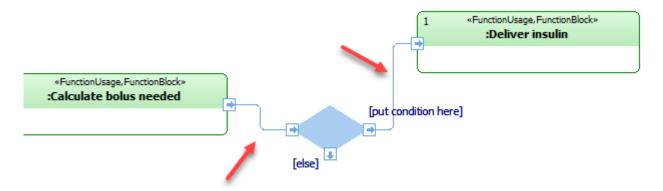


The display options are currently set-up to hide the type of these flow ports, hence we would read this as control flow. For info: we could type the flow-ports to show what flows, if that is more appropriate for the behavior, we are modeling

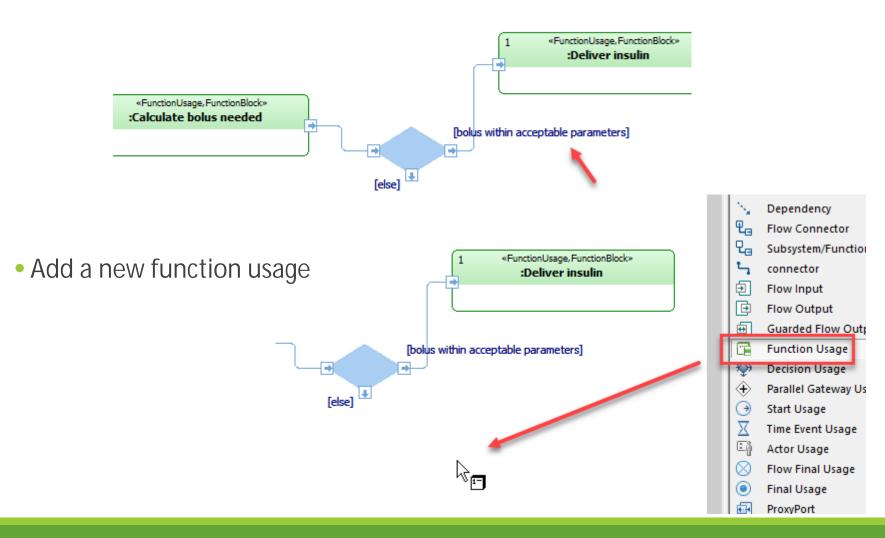
 The profile adds concepts to allow parallel and decision logic to be added to the ibd. Add a Decision Usage



Draw the flow connectors to wire the decision usage to the function usages



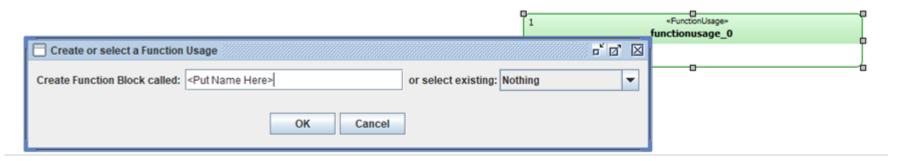
Add text to the guard condition: Bolus within acceptable parameters



Use dialog to create a new Function Block

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The helper provides a dialog to create a new function block or select an



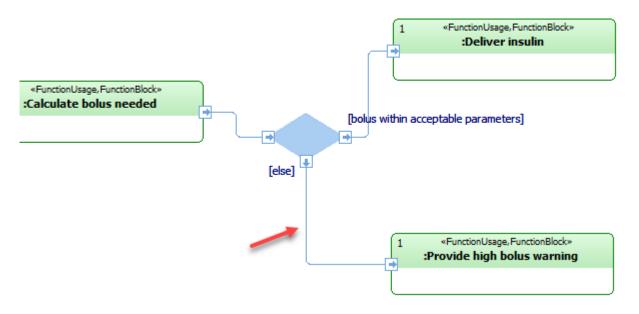


If you can't see this dialog, then it's possible it was launched behind Rhapsody or on a different screen

Call the function block: Provide high bolus warning and click OK

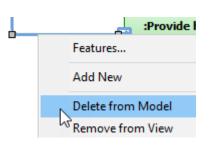


Add a Flow Connector to the new function usage

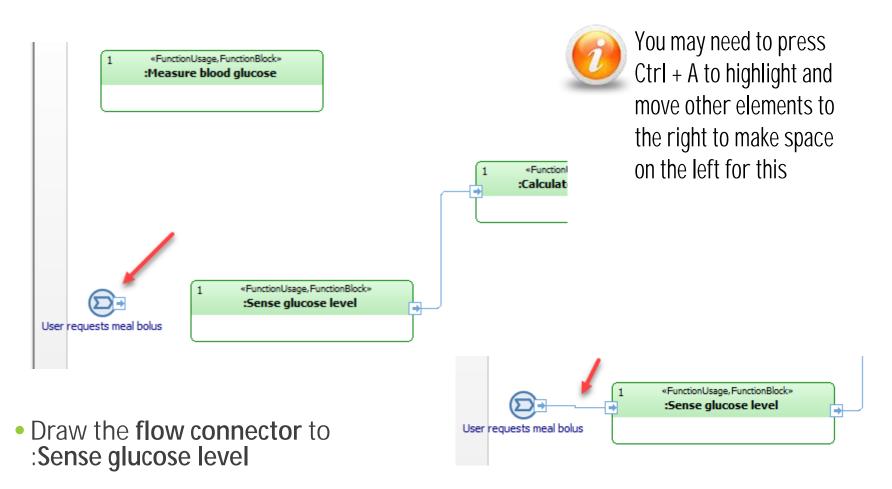




If you draw the wrong relationship or add a port you don't want, avoid pressing just the Delete key as the relationship and ports are not deleted from the model. Always Delete from Model rather than Remove from view, when drawing this diagram

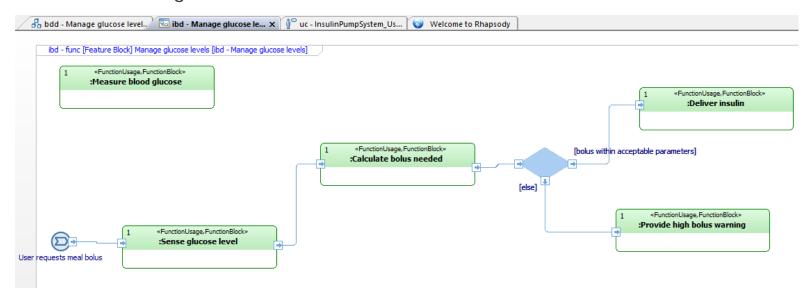


 Add an Accept Event Usage to show when the flow starts: User requests meal bolus



Review the diagram

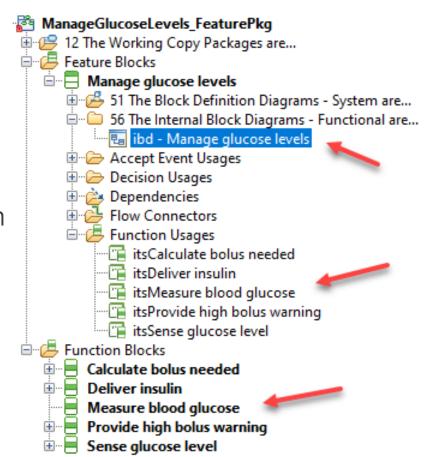
Review the diagram





Using the diagram toolbar provided by the profile we can build function chains using an internal block diagram. We can also decompose functions into their own internal block diagrams, similar to how call behavior actions in the activity diagram model work

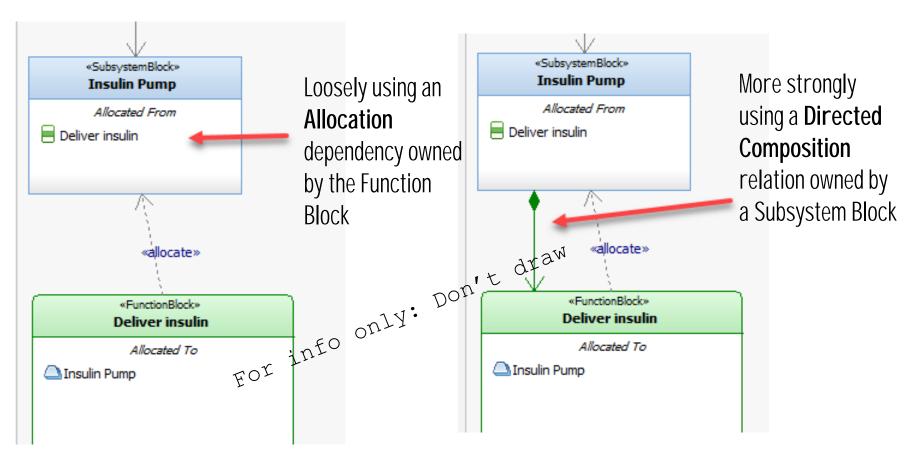
- Internal Block Diagrams are created underneath the element that defines them
- This diagram was created under a
 Feature Block and is therefore purely
 functional in nature, we've created a
 function chain of what the system
 may do, irrespective of how the
 system is decomposed
- The function chain is created between Function Usages of Function Blocks.
 The same function blocks can be reused in other features. The same function blocks can also be used to type function usages in the logical architectural model



For info: Allocation of function blocks to subsystems

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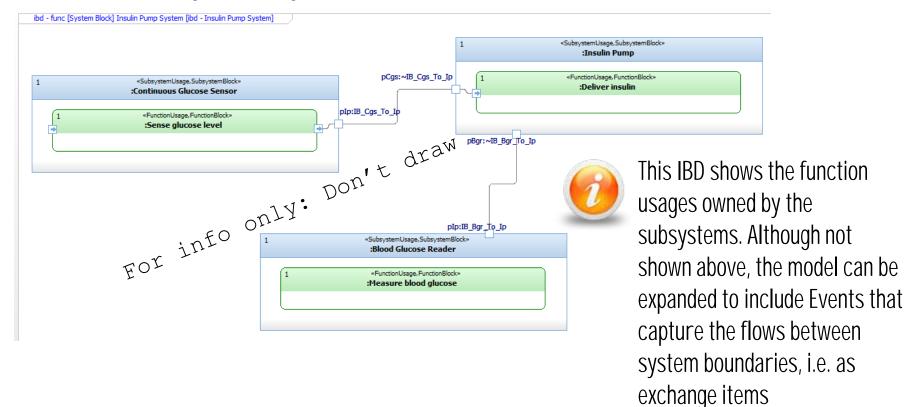
• There are two ways we can allocate these functions to structural definition elements. These two approaches are explored in different training module



For info: Mixing behavior and structure on same diagram

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 Use of Function Blocks enables the following notation to be achieved; a much closer relationship between behavioural and structural modeling than can be achieved with the activity model. E.g. You could show function chains inside a subsystem, if you wished



PACKAGE DIAGRAM - INDEX LAB IB4

"INSULIN PUMP" CASE STUDY

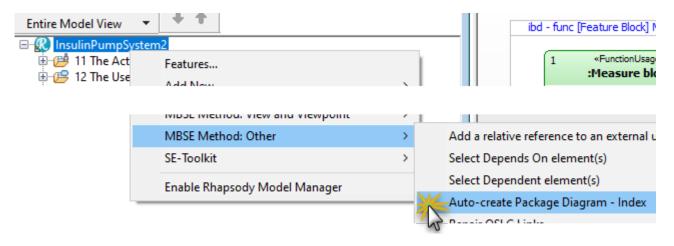
LAB IB4

"hear and I forget. I see and I remember. I do and I understand" (Confucius 551 BC - 479 BC)

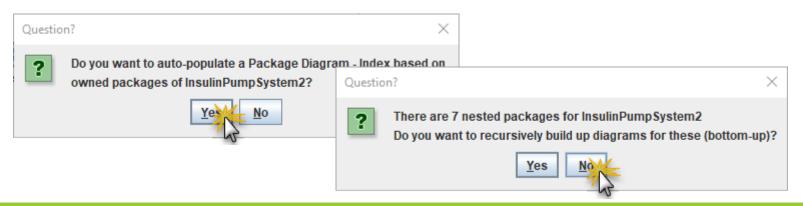


- As the model gets larger it becomes useful to have ways to navigate to diagrams of interest
- Package diagrams are a diagram type in SysML that show the model structure in terms of packages and how they might be related or decomposed into other packages
- Package Diagram Index is a New Term diagram type added by the Executable MBSE Profile. The category name ensures they are listed at the top of the list of elements
- Right-click menu functionality is provided in the MBSE Method: Other menu to create or update their contents automatically
- This lab explores this functionality

 Right-click the root of the project and choose MBSE Method: Other > Autocreate Package Diagram – Index

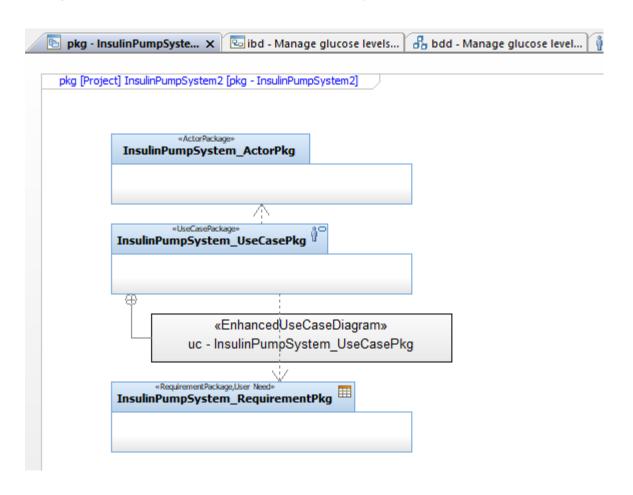


• Click Yes to confirm, and No to not recursively build up sub package diagrams

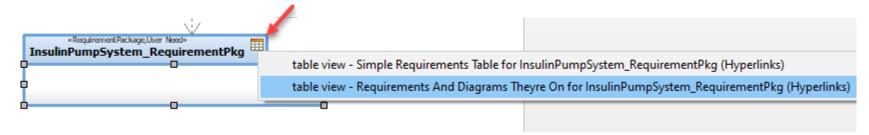


View the diagram

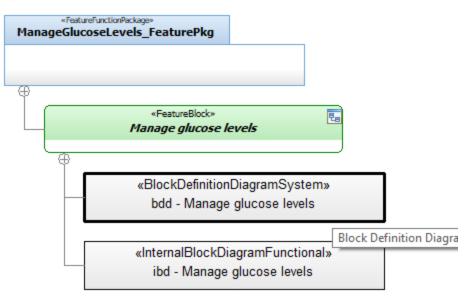
A package diagram – index is automatically created and opened



- Tables in the tree structure have been added as HyperLinks to enable navigation via the Quick Navigation icon for a package
- Right-clicking the icon will provide a list of tables, matrices, and diagrams



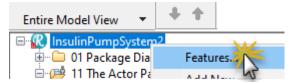
 Diagrams are nested under the element that owns them



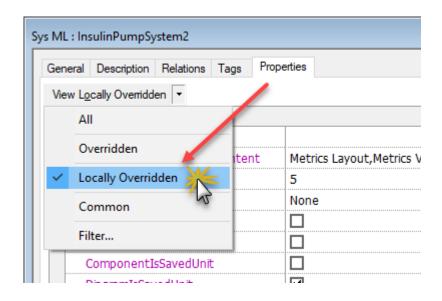
View Locally Overridden properties for the project

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 Let's enable the Enhanced Tooltip for diagrams. Open the Features... dialog for the project



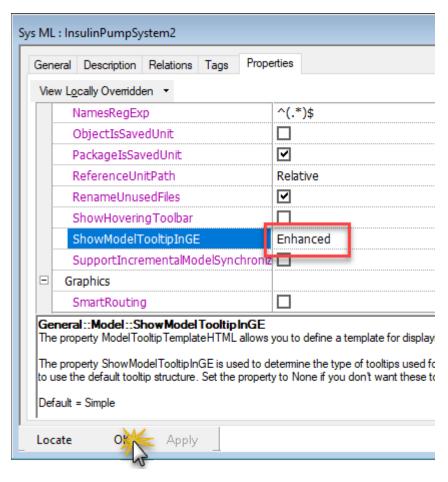
Go to the Properties tab and choose View Locally Overridden



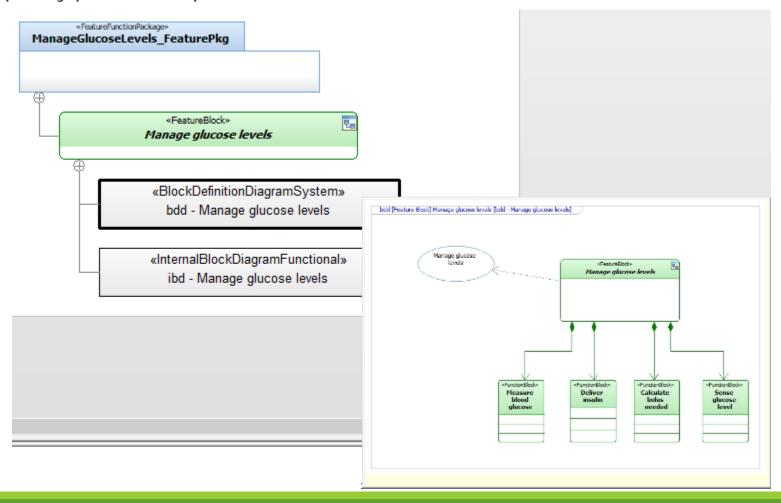
Change ShowModelTooltipInGE to Enhanced

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 Change the General::Model::ShowModelTooltipInGE to Enhanced. Click OK when done



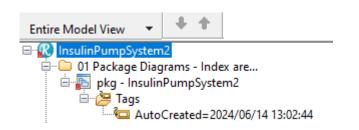
 Return to the Package Diagram – Index. If you hover over a diagram, then Rhapsody provides a preview of its contents



Auto-update Package Diagram - Index

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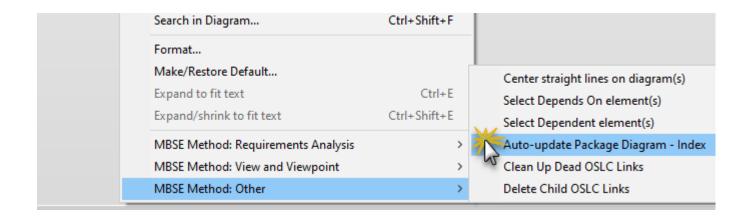
The diagram is auto-generated. An AutoCreated tag records the date/time



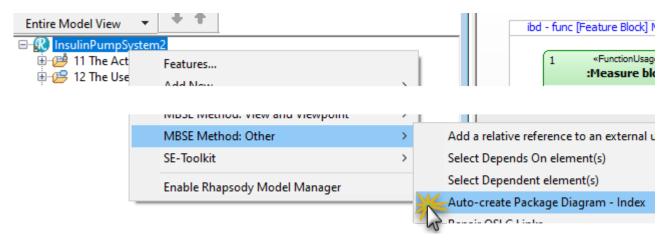


This tag is also used by the helper to locate diagrams when running an update

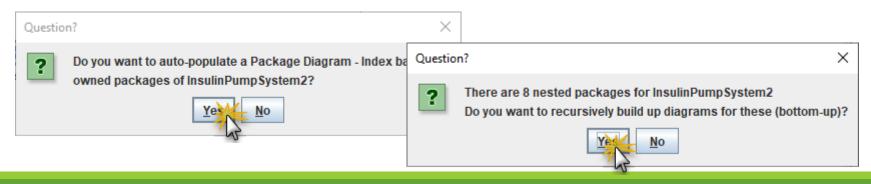
Menus allow you to re-create the contents if the model changes



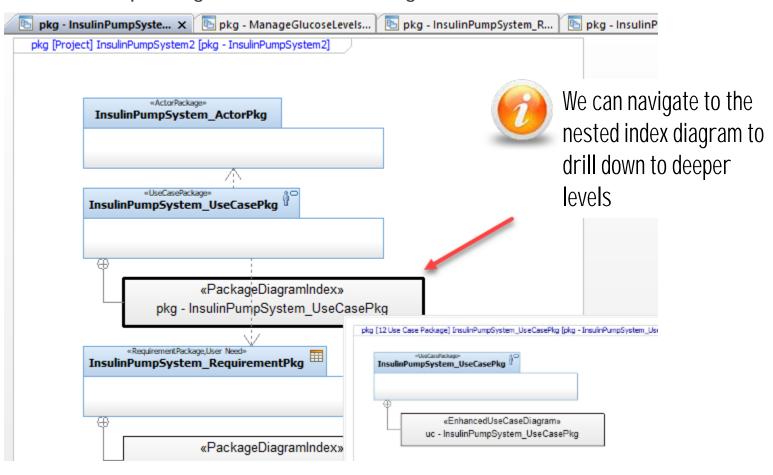
 Let's run it again. Right-click the root of the project and choose MBSE Method: Other > Auto-create Package Diagram – Index



 This time click Yes to confirm, and Yes to recursively build up sub package diagrams



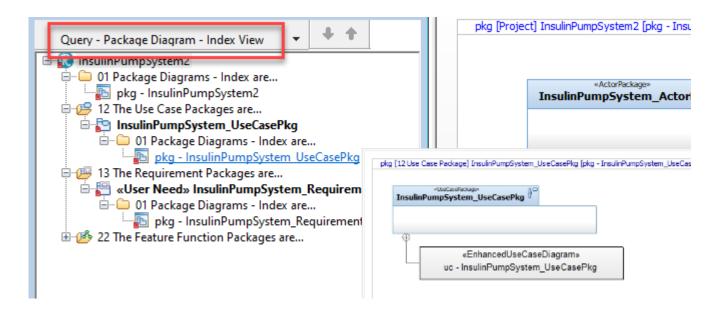
• This time the helper has created nested **Package Diagram – Index** diagrams for all the packages that contain diagrams or are root meta-classes



Query – Package Diagram Index Browser View

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The profile also adds a Query – Package Diagram – Index View which filters
the browser to just the index diagrams. Try this to finish





This can be used to navigate a complex model, or locate and delete package diagram – index's that you no longer want

INSTALLING THE SYSML HELPER Appendix A

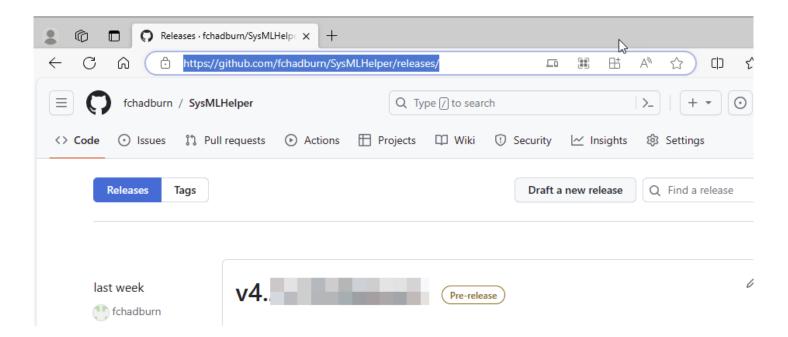
"INSULIN PUMP" CASE STUDY

APPENDIX A

"I hear and I forget. I see and I remember. I do and I understand" (Confucius 551 BC - 479 BC)



Go to https://github.com/fchadburn/SysMLHelper/releases/ to find the releases. I ocate the version needed

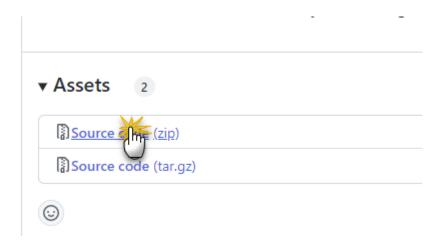




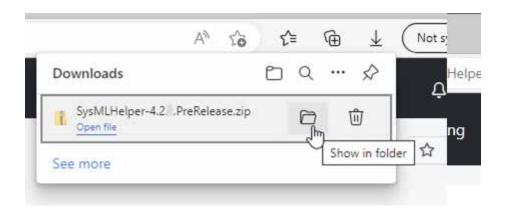
You can also visit my site at: http://www.executablembse.com/ which contains some further info on latest changes

Obtain profile from Github

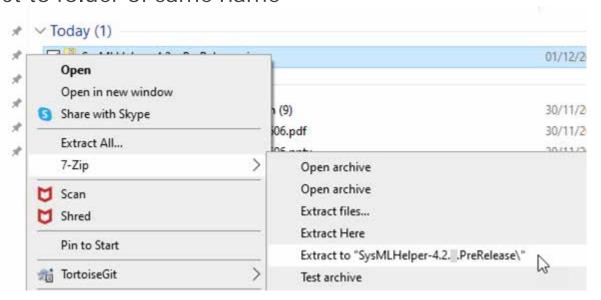
Click to download Source code (zip)



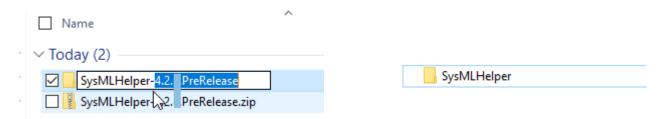
Locate file



Extract to folder of same name



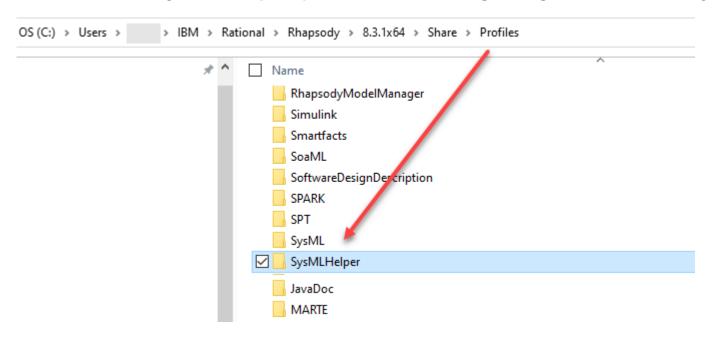
Remove the release part of name so top-level is called SysMLHelper



Locate your Rhapsody share/profiles folder

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- This is where Rhapsody's factory (out-of-the-box) profiles are located. E.g. in 9.0.1. this is C:\Program Files\IBM\Rhapsody\9.0.1\Share\Profiles
- This is where the SysMLHelper profile needs to go, e.g., 8.3.1x64 may be



 Delete, or move out, rather than rename the existing profile you have or overwrite over the top (this is very important as Rhapsody assumes only one .sbs/.sbsx file of a particular name exists under its Profiles folder)

Executable MBSEProfile properties

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• Many of the behaviors of the profile can be configured using properties

| | eral Description Relations Tags Properties | |
|---|--|--|
| _ | Dialog Eclipse | |
| 1 | | |
| 1 | | |
| 3 | DesignSynthesis | |
| 3 | FunctionalAnalysis | |
| 3 | General | |
| | AllowPluginToControlUnitGranularity | |
| | AutoGenerationOfPackageDiagramContentPolicy | UserDialog |
| | DontCreateSeparateUnitNewTerms | |
| | EnableDebugLogging | |
| | EnableErrorLogging | ✓ |
| | EnableInfoLogging | ✓ |
| | EnableLogFile | |
| | EnableWarningLogging | ✓ |
| | IsDoubleClickFunctionalityEnabled | ✓ |
| | IsShowProfileVersionCheckDialogs | ✓ |
| | Package Diagram Index Is Auto Complete Relations Enabled | ✓ |
| | PackageDiagramIndexLeafElementMetaClasses | 11 Actor Package, 13 Requirement Package, Pa |