

# Reach/Coreach Tool

July 2016



McMaster Centre for Software Certification (McSCert)

# 1 Introduction

The Reach/Coreach tool is used to trace and highlight data flow and control flow dependencies in Simulink models. Performing a *reachability analysis*, or “*reach*”, on a portion of the model will show the effects that it has on other parts of the model. A *coreachability analysis*, or “*coreach*”, does the opposite, by showing what a portion of the model is dependent on.

The tool has many uses:

- The reachability and coreachability analyses effectively generate a dependency diagram of data and control flow in the model. This assists with model comprehension, and is also useful in identifying areas of the model where seemingly independent data flows have hidden dependencies.
- The tool supports impact analysis, because it identifies the parts of a model affected by a potential change of a given block. Impact analysis can be of great value in indicating what effect a change in requirements or design can have on system’s design.
- The tool can be used to find unreachable parts of a model. When reachability analysis is performed on all of a model’s inputs, unhighlighted blocks/signals represent unreachable parts of the model.
- When the coreachability analysis is performed on all of a model’s outputs, the unhighlighted blocks/signals are unnecessary in the sense that they have no (data or control) effect on the outputs of the model.
- The tool can isolate a model into smaller pieces for further analysis, by *slicing* out the highlighted traces.

For more information, one can refer to the published conference paper:

Vera Pantelic, Steven Postma, Mark Lawford, Alexandre Korobkine, Bennett Mackenzie, Jeff Ong, and Marc Bender, “A Toolset for Simulink: Improving Software Engineering Practices in Development with Simulink,” *Proceedings of 3rd International Conference on Model-Driven Engineering and Software Development (MODELSWARD 2015)*, SCITEPRESS, 2015, 50–61.

## 2 How to Use the Tool

### 2.1 Prerequisites

Please ensure the following, before using the tool:

- Use MATLAB/Simulink 2011b or newer.
- The tool is present in your MATLAB path. If it is not, go to **File > Set Path...**, press **Add with Subfolders**, and select the **McMaster\_Tools** folder. Restart MATLAB after doing so.
- The model is open.

## 2.2 Getting Started

The tool can be used via the Simulink Context Menu, which can be viewed by right-clicking in a model. The following options can be available in the Reach/Coreach menu, depending on what is selected in the model (as shown in Figure 1).

- *Reach From Selected* – Available at all times.
- *Coreach From Selected* – Available at all times.
- *Reach/Coreach From Selected* – Available at all times.
- *Clear Highlighting* – Available when a reach and/or coreach are present in the model.
- *Slice* – Available when a reach and/or coreach are present in the model.
- *Set Colour* – Available at all times.

## 2.3 Functionality

### Reach From Selected

Right-clicking on one or more blocks in the model and then selecting **Reach From Selected** from the Context Menu will perform a reachability analysis, and highlight the blocks and signals which are affected by those selected blocks. The highlighting illustrates what parts of the model are dependent on the selected blocks, due to control flow or data flow.

### Coreach From Selected

Right-clicking on one or more blocks in the model and then selecting **Coreach From Selected** from the Context Menu will perform a coreachability analysis, and highlight the blocks and signals which affect those selected blocks. The highlighting illustrates what parts of the model the selected blocks depend on, due to control flow or data flow.

### Reach/Coreach From Selected

Right-clicking on one or more blocks in the model, and then selecting **Reach/Coreach From Selected** from the Context Menu will perform both reachability and coreachability analyses on the selected blocks. The highlighting illustrates, bidirectionally, what parts of the model either impact, or have an impact, on the selected blocks, due to control flow or data flow.

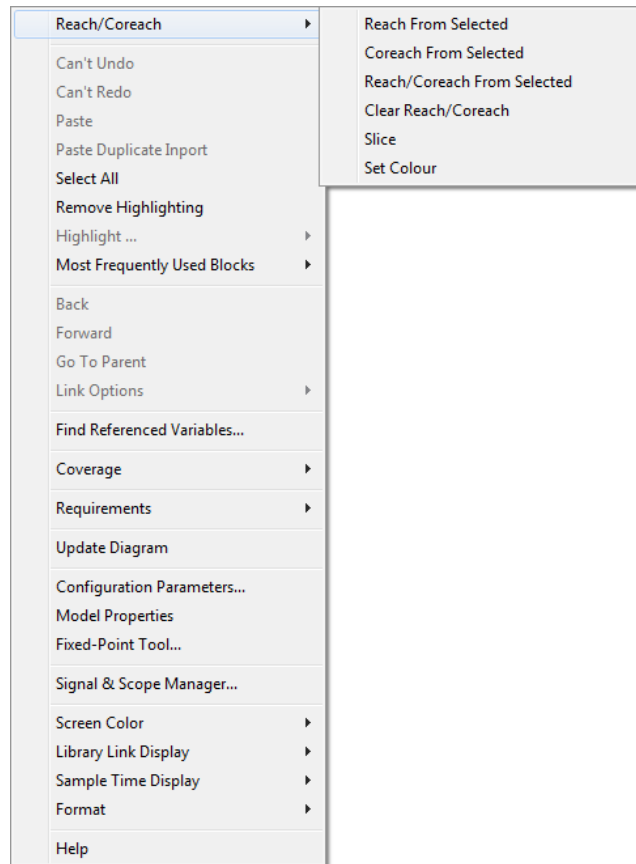


Figure 1: Simulink Context Menu with tool options visible

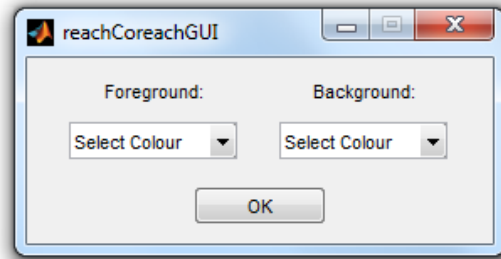


Figure 2: Highlight color selector interface

### Clear Highlighting

After a reach, coreach, or reach/coreach are performed on the model, this option will be enabled. Right-clicking anywhere in the model, and then selecting **Clear Highlighting** from the Context Menu will clear all highlighting in the model.

### Slice

After a reach, coreach, or reach/coreach are performed on the model, this option will be enabled. Right-clicking anywhere in the model, and then selecting **Slice** from the Context Menu will isolate the highlighted parts of the model by removing the non-highlighted blocks and lines.

### Set Colour

Right-clicking anywhere in the model and then selecting **Set Colour** from the Context Menu will display the user interface shown in Figure 2. The foreground (text and line) and background (block) highlight colours can be customized via the drop down menus, which provide the standard Matlab colours. Clicking OK will use the selected colours for all current and future highlighting in the model. The default colours are red (foreground) and yellow (background).

## 2.4 Errors and Warnings

Any errors or warnings during tool use will be visible in the MATLAB Command Window. Typically, errors will be shown when the model is locked or function parameters are incorrect.

## 3 Example

Use the command `ReachCoreachDemo` in the Simulink command window to open the example model, shown in Figure 3. This example has control and data flow pass through **Data Stores**, **If** and **If Action** subsystems, as well as a

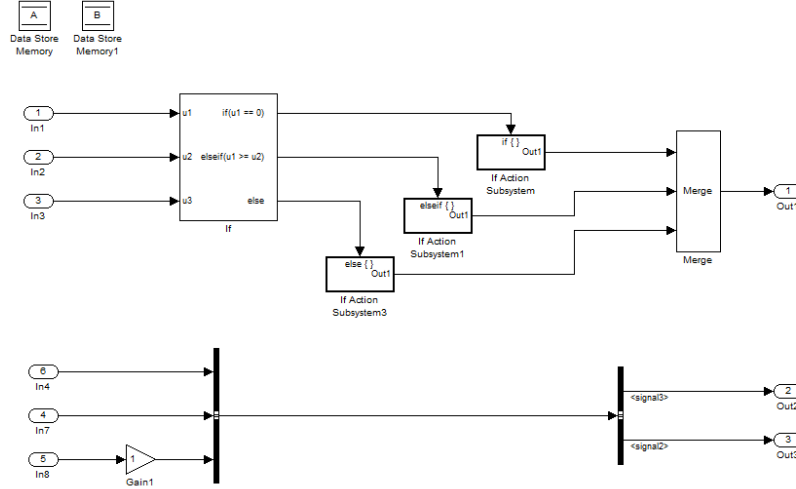


Figure 3: Reach/Coreach demo model

Bus Creator and Bus Selector. The following steps will demonstrate the various functionalities of the tool.

1. Let us perform a reachability analysis to find all possible dependencies of the Inport block In2. To do this, right-click on the In2 block and select the **Reach From Selected** option. The resulting model is shown in Figure 4. Due to the fact that In2 is used in the last two condition checks of the If block and its data flow is traced to Outport block Out1. Doing a reachability analysis on In2 also shows clearly that it impacts the Data Store Memory block A.
2. To clear the highlighting now present in the model due to the previous reach operation, right-click anywhere in the model and select the **Clear Highlighting** option. This will revert the model's appearance to that of Figure 3.
3. Let us perform a coreachability analysis to find all the parts of the model which the Outport blocks Out2 and Out3 are dependent on. To do this, select both blocks, right-click on them, and select the **Coreach From Selected** option. The resulting model is shown in Figure 5. Blocks Out2 and Out3 are dependent on the Inport block In7 and In8 only, and it is interesting to note that In6 has no impact in the model.
4. We can isolate the coreachability analysis by performing a slice. To do so, right-click anywhere in the model and select the **Slice** option. All blocks

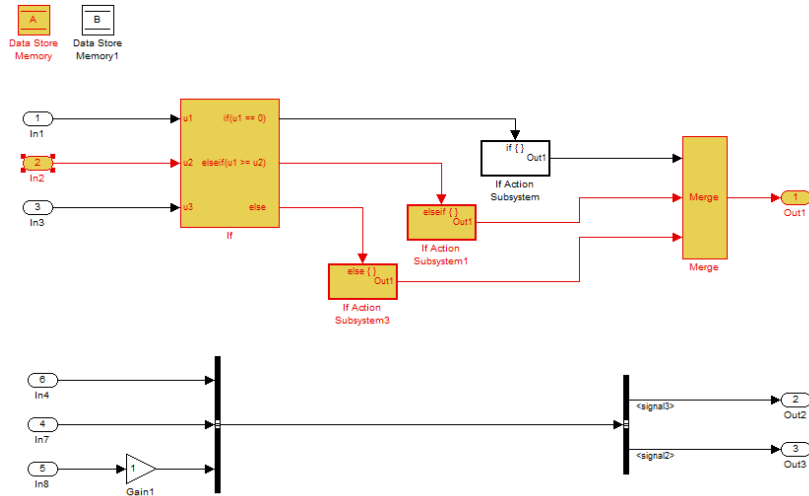


Figure 4: Resulting model after **Reach From Selected** operation

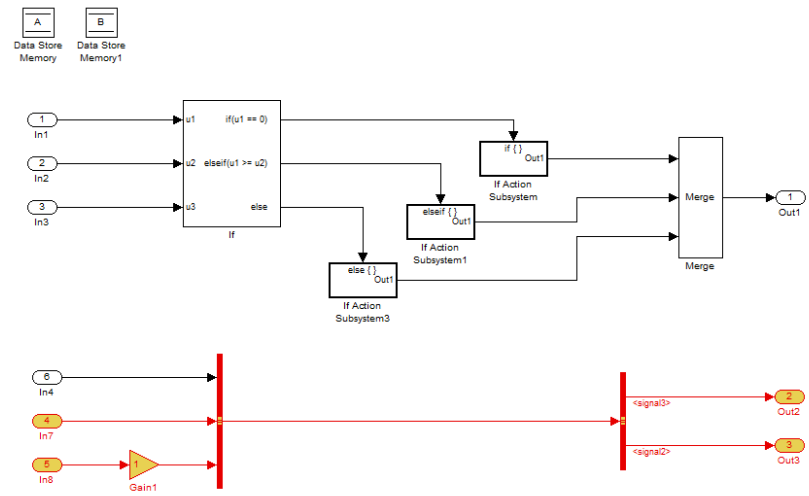


Figure 5: Resulting model after **Coreach From Selected** operation

and signals which are not highlighted will be deleted from the model. The resulting model is shown in Figure 6.

- Let us now perform a reach/coreach in the model. First, reopen the demo model, so as to start from new. Right-click on **Data Store Memory B**, and select the **Reach/Coreach From Selected** option. The resulting model

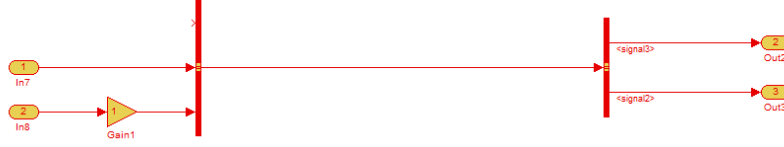


Figure 6: Resulting model after **Slice** operation

is shown in Figure 7. By doing both a reachability and coreachability analysis on this block, we can see the total impact that this block has on the model. In this case, no other blocks or signals are highlighted, meaning that this block has no purpose in the mode. It is not used by anything, nor does it perform any operation itself. This block can be considered “dead code”, and should be removed from the design.

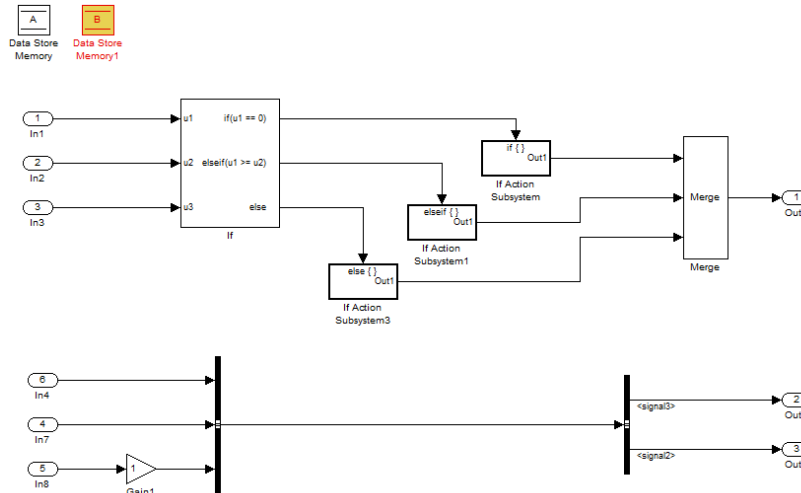


Figure 7: Resulting model after **Reach/Coreach** operation



## 4 Matlab Commands

The tool can also be used via the MATLAB command line, with the following classes and functions.

|                 |  |
|-----------------|--|
| Function        | <b>ReachCoreach</b>  |
| Syntax          | <b>obj = ReachCoreach(<i>modelName</i>)</b>  |
| Description     | Create a new ReachCoreach object for <i>model</i> .  |
| Input Arguments | <i>modelName</i> : The Simulink model name (or top-level system name) of the model on which to perform reach/coreach operations. |

|                 |   |
|-----------------|---|
| Function        | <b>reachAll</b>   |
| Syntax          | <b>obj.reachAll(<i>blocks</i>)</b>  |
| Description     | Perform a reachability analysis starting from <i>blocks</i> .                             |
| Input Arguments | <i>blocks</i> : A cell array of block path names from which to start the reach operation. |

|                 |   |
|-----------------|---|
| Function        | <b>coreachAll</b>   |
| Syntax          | <b>obj.coreachAll(<i>blocks</i>)</b>  |
| Description     | Perform a coreachability analysis starting from <i>blocks</i> .                             |
| Input Arguments | <i>blocks</i> : A cell array of block path names from which to start the coreach operation. |

|                 |  |
|-----------------|--|
| Function        | <b>clear</b>                             |
| Syntax          | <b>obj.clear()</b>                       |
| Description     | Clear any reach or coreach highlighting. |
| Input Arguments | N/A                                      |

|                 |  |
|-----------------|--|
| Function        | <b>slice</b>   |
| Syntax          | <b>obj.slice()</b>   |
| Description     | Isolate the reach/coreach blocks by removing unhighlighted blocks. |
| Input Arguments | N/A  |

|                 |  |
|-----------------|--|
| Function        | <b>setColor</b>  |
| Syntax          | <b>obj.setColor(<i>foregroundColor</i>, <i>backgroundColor</i>)</b>                    |
| Description     | Set the colour of the reach/coreach highlighting.                                      |
| Input Arguments | <i>foregroundColor</i> : A Matlab colour.<br><i>backgroundColor</i> : A Matlab colour. |

**Example:** The following commands perform the same operations as described previously for the `ReachCoreachDemo` example, however via the Matlab command line.

```
1. r = ReachCoreach('ReachCoreachDemo')
2. r.reachAll({'ReachCoreachDemo/In2'})
3. r.clear()
4. r.coreachAll({'ReachCoreachDemo/Out2','ReachCoreachDemo/Out3'})
5. r.slice()
```