

Circuit Design Editor Manual

Alexios Koukoulas 2074245

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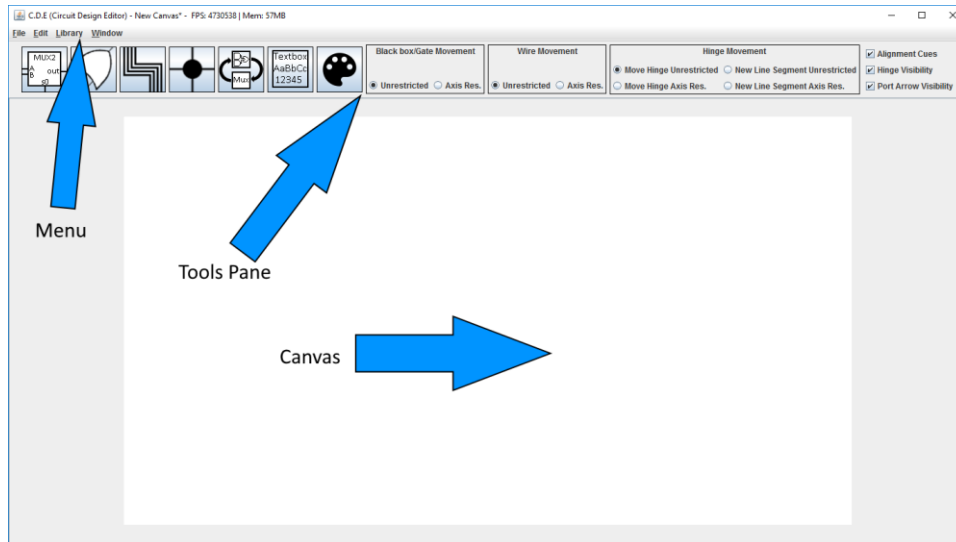
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Introduction

This document is aimed at gently and hands on introducing the user to all the features (up until the point of writing) of the editor. The order in which concepts are introduced, closely resembles the criticality of the concept and the likelihood that the concept will be important early on.

Window structure and orientation

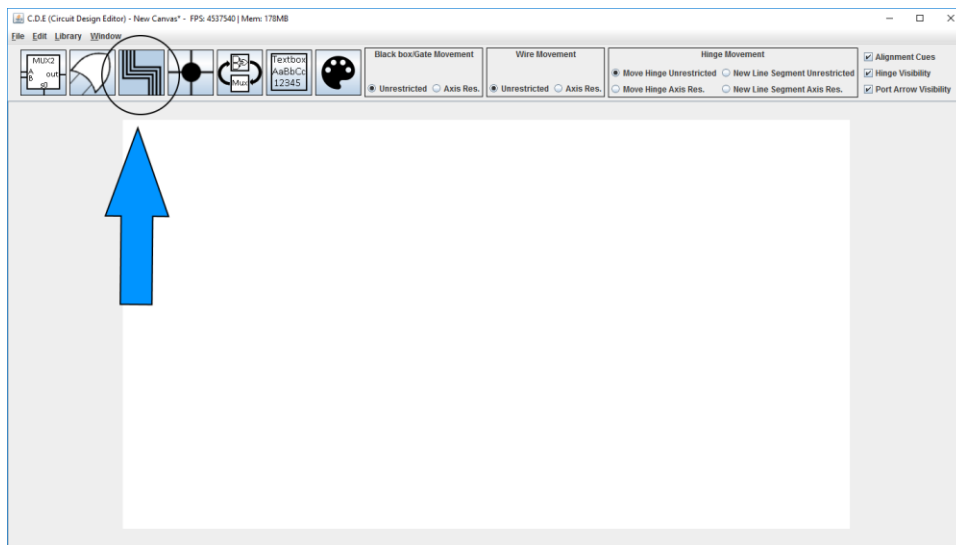
When the editor is launched it should look similar to the image below. In the image, the three most important areas of the editor are highlighted. The "Canvas Area", which is the main drawing area and is where the current state of the system can be observed and directly manipulated, the "Tools Pane", where the most impactful and frequent tools the user can take advantage of are present, and the "Menu" which contains actions that are concise and will not be used as frequently as the tool pane, or actions which can simply be achieved by keybindings and hence they don't to take as much space in the window.



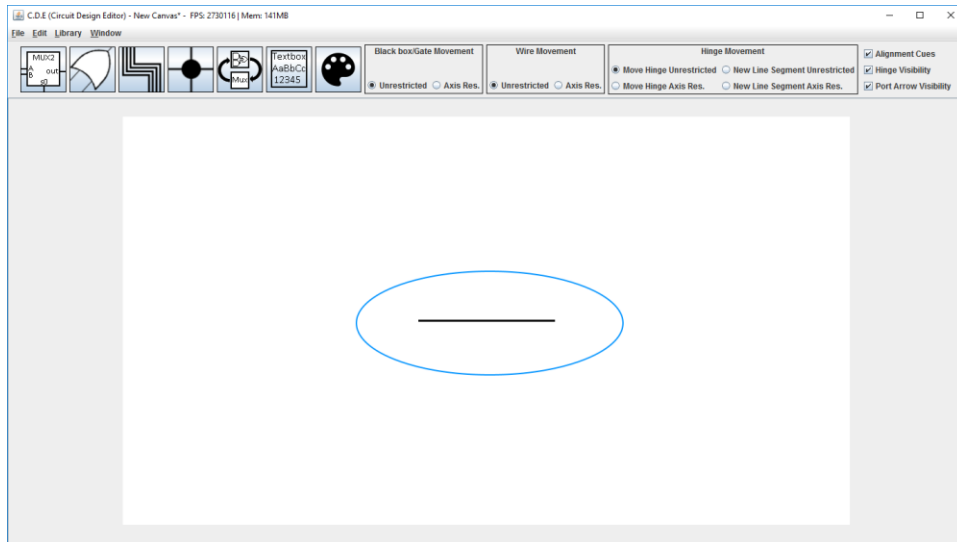
Placing, Selecting, Moving and Extending a line segment to create a system

In this section we will experiment with line segments and hinges and learn about the various ways we can manipulate them.

1) Let's begin by clicking with the left mouse button the "Wire Button" (3rd leftmost button) in the "Tools Pane"



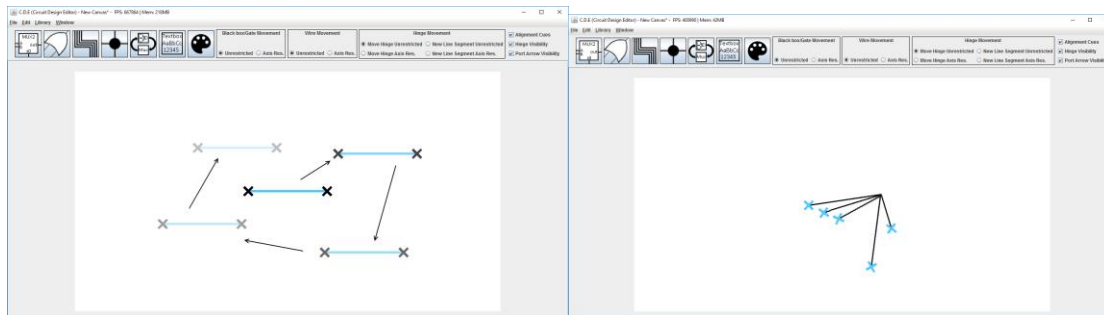
2) We can now observe a line appearing in the middle of the canvas area.



3) By hovering over the new line segment with the mouse, we will notice either the core line or one of its two end points (Hinges) being highlighted depending on the location of the mouse.



4) If we now try dragging with the left mouse button, depending on the component highlighted, the (very small) system will react differently.

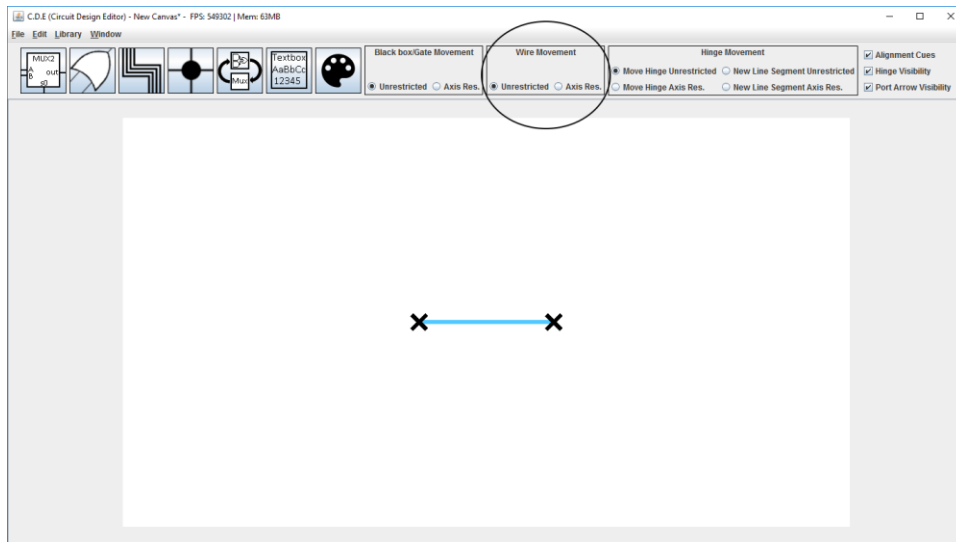


We can see that line segments will freely move around the canvas, while hinges will be positioned under the current location of the mouse cursor. In essence the two hinges are children of the parent line

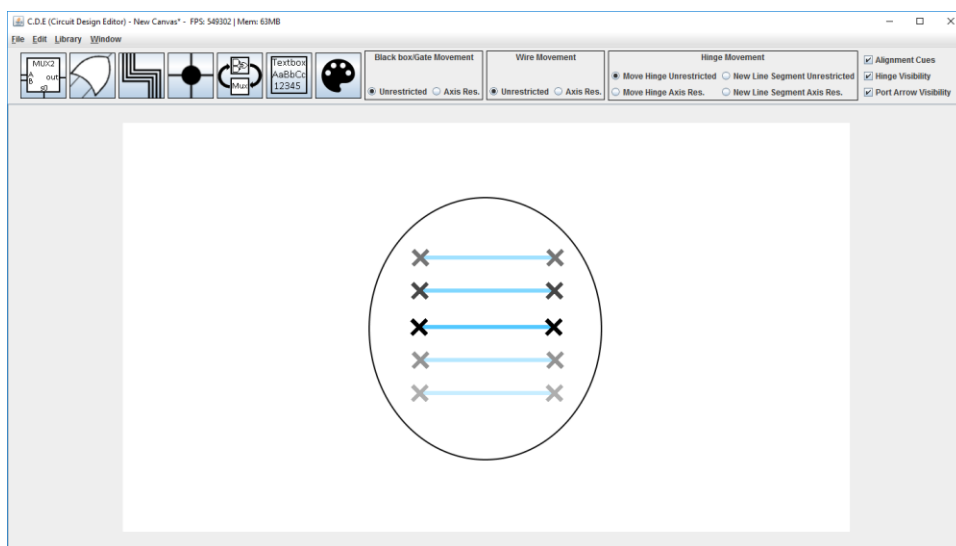
segment, and hence when the parent moves the children will also be directly affected. Lastly selected components will always appear blue so they can be easily distinguished from other components.

5) The type of movement for each type of component is displayed and can be changed in the respective component's movement box in the Tool's Pane by selecting the various radio buttons available.

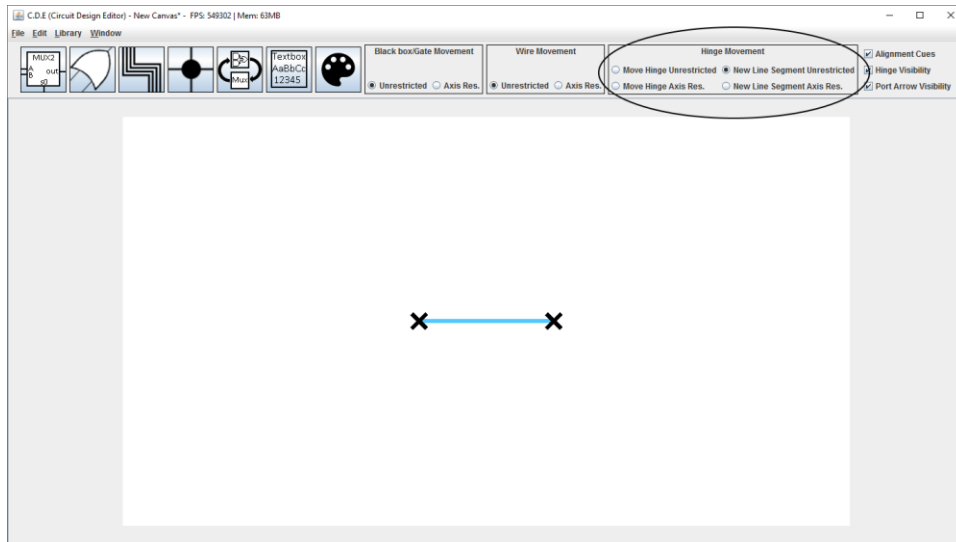
For instance if we want to restrict the movement of line segments to the axis respective to their orientation, we can select the Axis Res. radio button in the Wire Movement Panel:



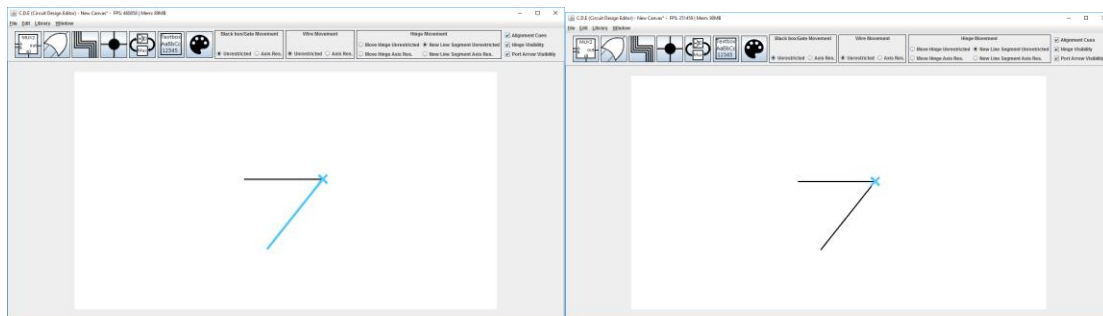
If we now try to move the line segment we can see that its movement is restricted to the y-axis due to its horizontal orientation:



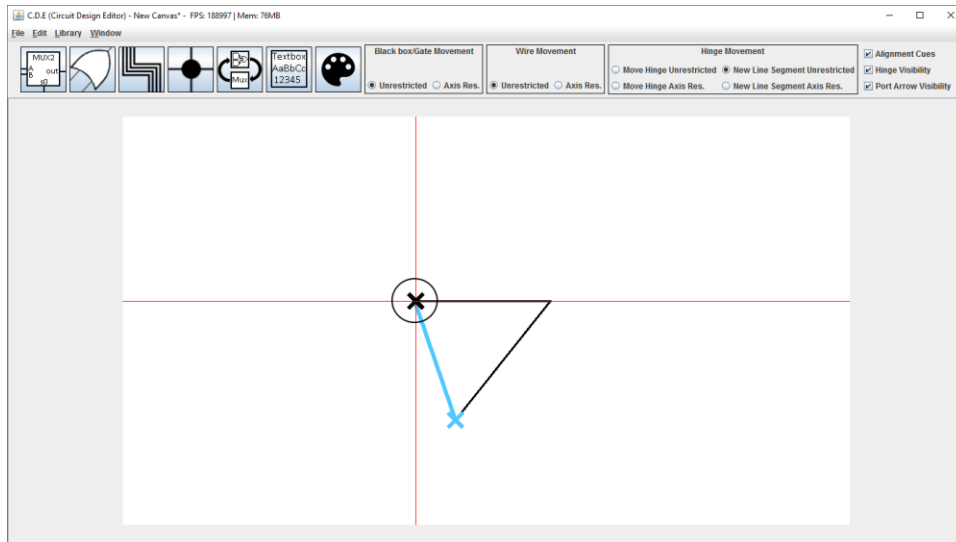
6) While hinges also have similar movement options to the line segments, they can also create new/extend line segments. Let's select the "New Line Segment Unrestricted" radio button in the Hinge Movement panel:



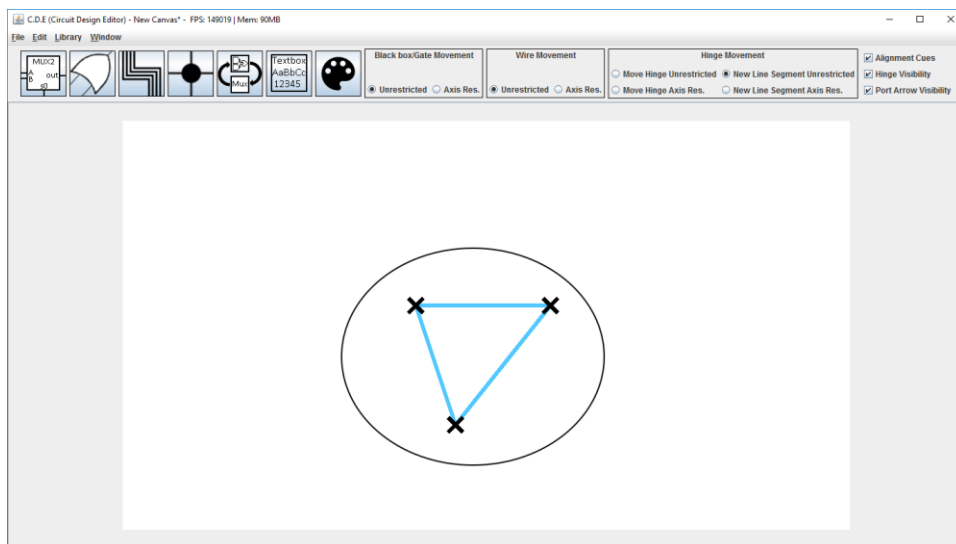
If we now try to drag a hinge, instead of moving, it will spawn a new line segment and finalize it by releasing the left mouse button:



Importantly, If we try to create a new line segment from a hinge and finalize it on top of another hinge, the two hinges will merge and hence the result will be a closed system like a triangle in our case:

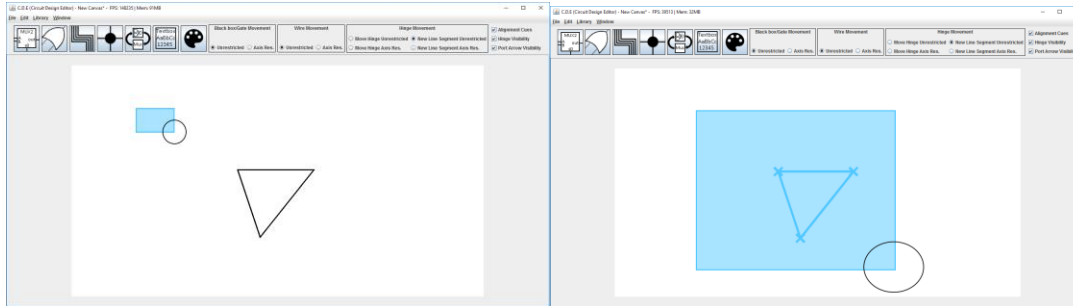


We can always verify that a system is indeed a closed system by pressing and holding the left mouse button on any segment of the system which will in turn force all the interconnected components to be colored blue as well:

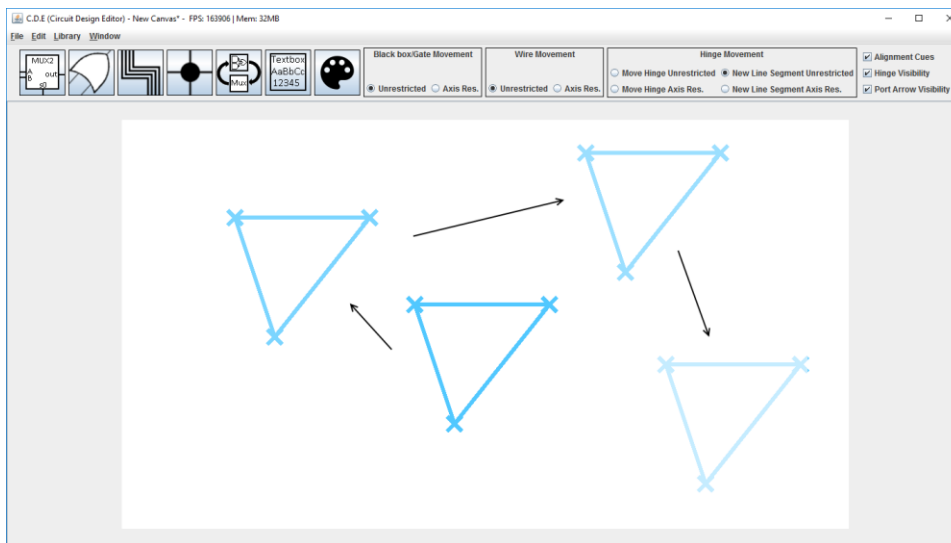


7) Positioning a small system wherever we wish can easily be done by manually moving each line segment or hinge to the desired location, but what if the system was comprised of thousands of components? That's where multi selection comes to play.

To make a multi selection, start by pressing the left mouse button on an empty space in the canvas, and then by dragging around the mouse, enclose the components we want to select in the rectangular area:



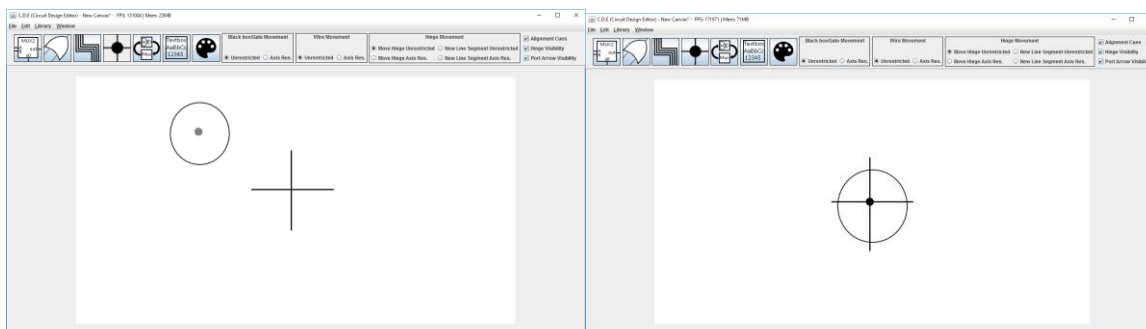
We can now freely move our selection around the canvas by dragging one of the selected components around as if it was a single component:



Component specific movement properties such as line segment extensions, axis restricted movement etc do not apply for multi selection movement, which is always unrestricted.

8) Let's now delete the triangle by (selecting all components again if not selected) and by pressing the Delete key or by selecting Edit->Delete from the menu.

9) Lastly to denote electrical connection and connect two line segments into a system we can drag and drop a "dot" from the "Tool's Pane" to the intersection of the lines:



The dots will always bind to either line segments or hinges (hinges will always have higher priority), or will disappear if released on empty space or another type of component. If released on a 2-or-more line

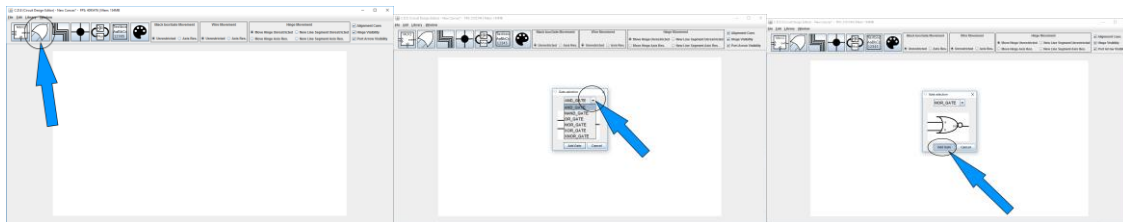
segment intersection like in the example, the dot will effectively interconnect the two previously disconnected lines to four connected line segments, which can be observed if the new hinge is moved around the canvas.

Practice Exercise: Create an interconnected rectangle

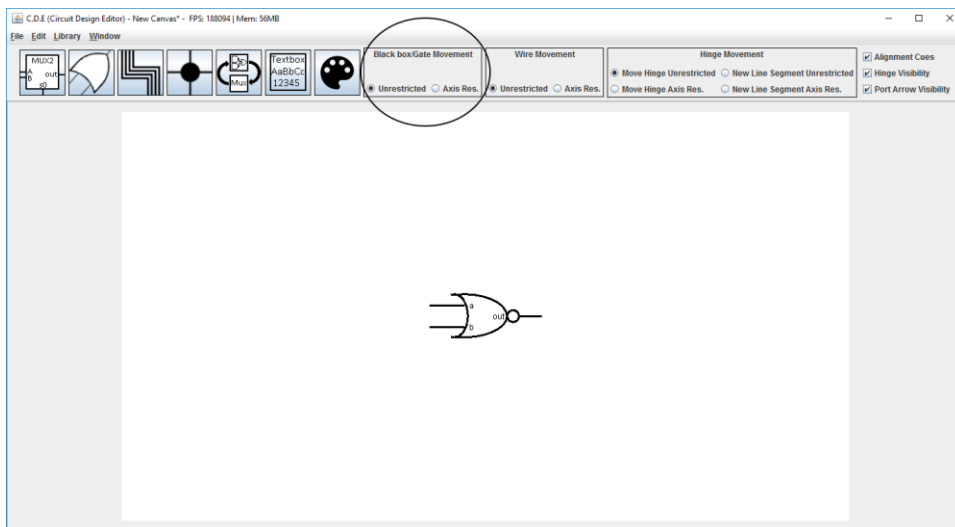
Logic Gates and bigger systems

Now that the basics of movement and selection are clear we can introduce Logic Gates. In the editor, logic gates behave quite similarly to line segments and hinges. They can be moved around individually in various ways, connect their ports to other systems and be manipulated in a multiple selection too. Gates also have immovable ports, which are in essence immovable line segments, through which they can be connected to other systems

1) To create a Logic Gate first click on the Logic Gate Button in the Tool's Pane (2nd leftmost button), then select the desired logic gate type, and finally press add gate:

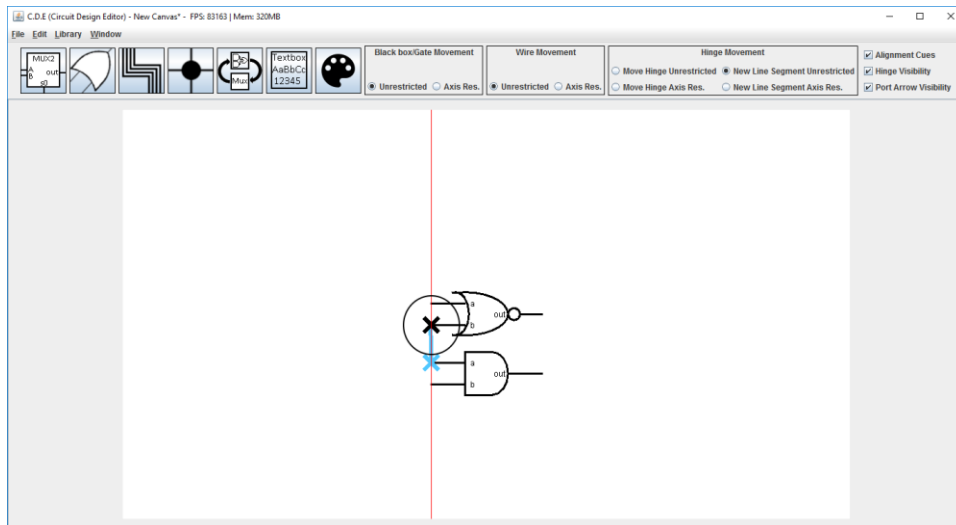


2) Like the rest components we've covered so far, gates also have two different types of movement under Black box/Gate Movement panel:

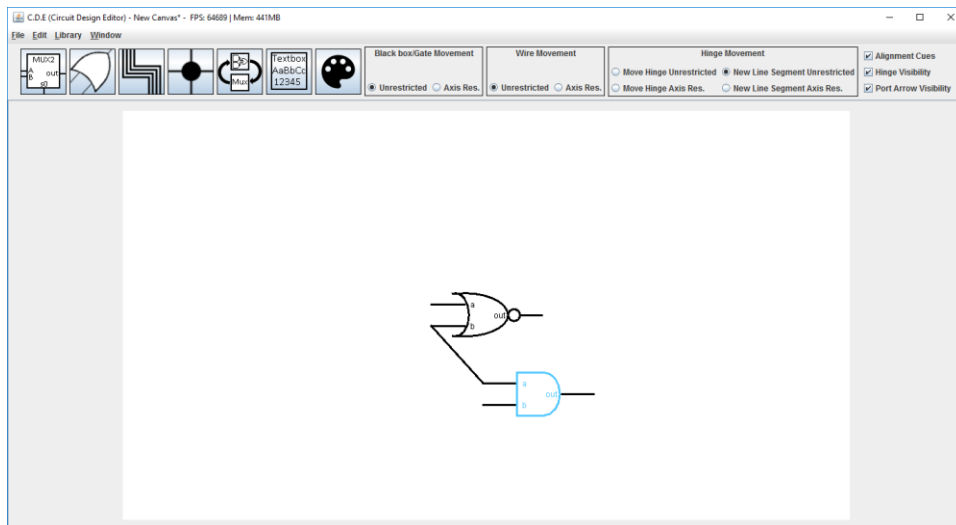


Gates can be moved around freely (unrestricted movement), or be moved by keeping the starting points of their ports fixed (Axis Res. Movement).

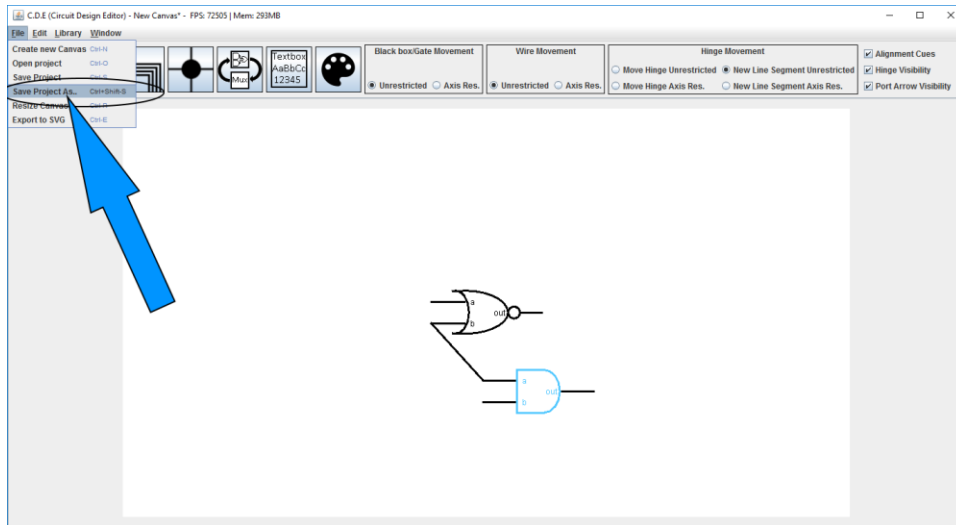
3) Let's try now to create a system by connecting two gates together. To do this, we can create a second gate by following the instructions presented at point 1), then selecting the "New Line Segment Unrestricted" radio button in the Hinge movement panel, and finally dragging a new line starting from a port of the first gate to a port of the second gate:



We can now notice the side effects of the system by moving a gate around:



4) At this point we might want to save our progress to a file, or export the system as an SVG file. Both of these options are available in the File menu or with their respective keybindings CTRL+SHIFT+S and CTRL+E:

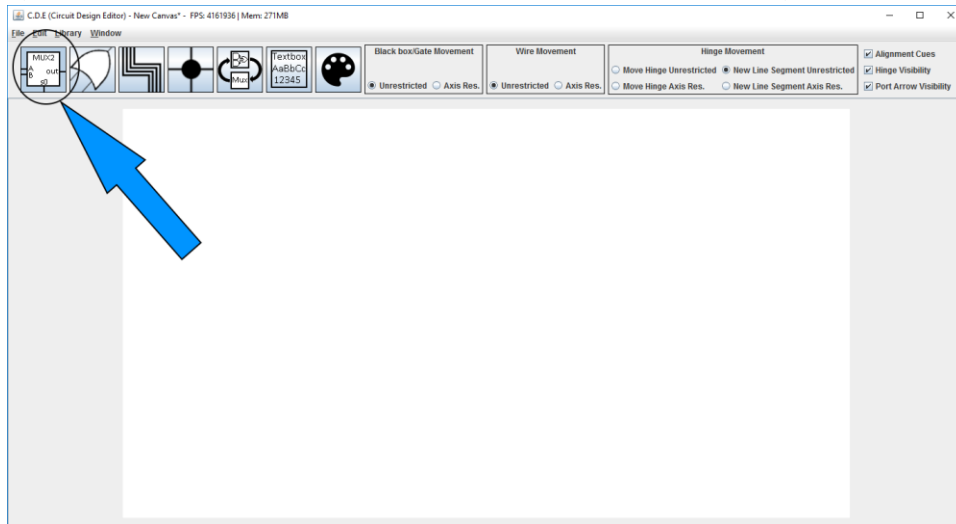


Practice Exercise: Create a multiplexer circuit and save it to a file

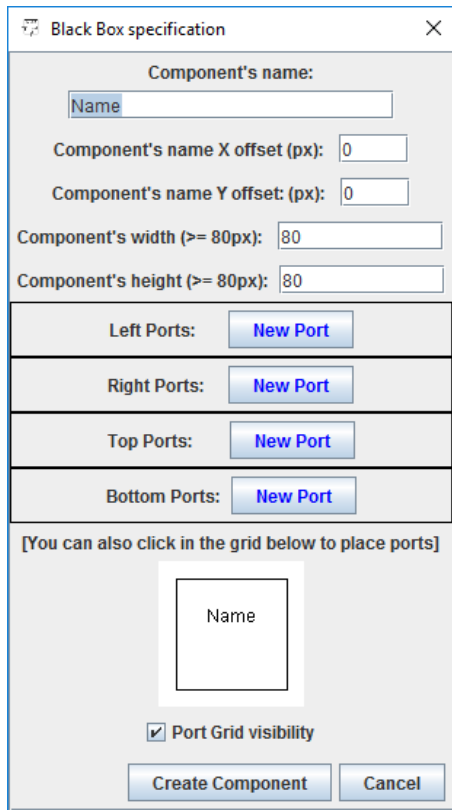
Black Boxes

Black boxes are very similar to logic gates in that they share the same global movement type and have ports, but are fully customizable and parameterizable.

1) To create a black box let's first click on the "Black Box Button" (1st leftmost button in the Tool's pane):



2) The black box specification window that appears might seem confusing but all the options are very straightforward:



Black Box specification

Component's name:

Component's name X offset (px):

Component's name Y offset (px):

Component's width (>= 80px):

Component's height (>= 80px):

Left Ports:

Right Ports:

Top Ports:

Bottom Ports:

[You can also click in the grid below to place ports]

Name

☒ Port Grid visibility

Let's have a look at the options in order:

- First and foremost we can specify the desired name for the component we are about to create.
- Next we can specify an offset for the name to position it wherever we desire.
- Furthermore we can give the component an arbitrary width and height as long as it is above the minimum values specified on the left.
- The next section in the specification window is the "ports" section. Here we can automatically place ports to the component by clicking on the respective area (left, right, top, bottom) where we want the port to be created. We can then manually change the name and position of the port, set it to inverted, or set an arrow indicating input or output for the target port. The changes on the system will be reflected on the port preview canvas below.
- As the label below suggests, we can also directly add ports to the component by clicking inside the canvas in the preview panel. Adding new ports this way will also be reflected in the ports section above and we can then rename and place the newly created ports to an exact location if we so desire.

Black Box specification
✕

Component's name:

Component's name X offset (px):

Component's name Y offset (px):

Component's width (>= 100px):

Component's height (>= 100px):

Left Ports: New Port

Right Ports: New Port

Port:
☐ Inv
☐ Out
☐ In
Y (px):
Delete

Top Ports: New Port

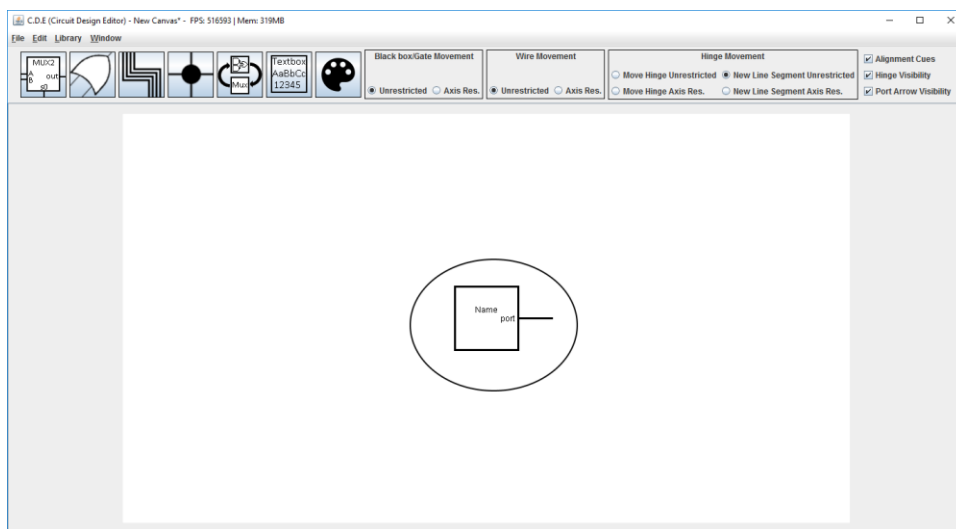
Bottom Ports: New Port

[You can also click in the grid below to place ports]

☒ Port Grid visibility

Create Component
Cancel

3) Finally we can create the component by clicking in the "Create Component" button or "Cancel" to cancel the whole process and return to the main window:

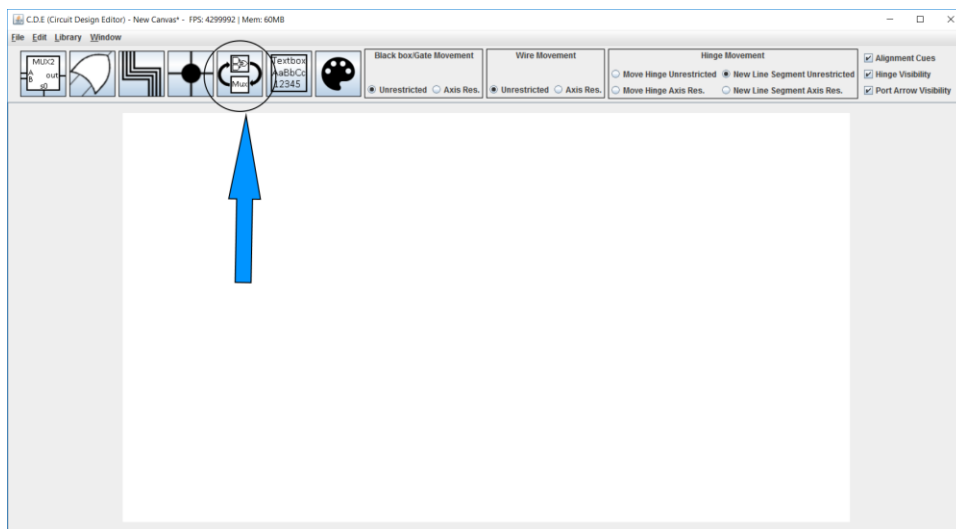


Apart from their slightly more elaborate creation process, black boxes behave almost identically to gates in the canvas area. As mentioned before they also share the same global movement type (Black Box/Gate Movement panel).

Practice Exercise: Create a 4 bit ripple carry adder circuit and save the circuit to a file.

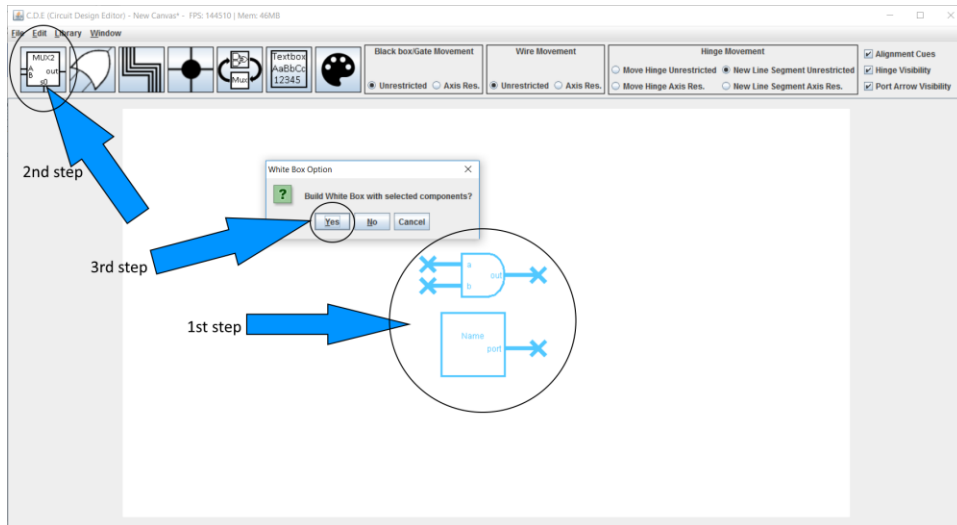
White Boxes

The last big component type we will cover are White Boxes. White boxes are essentially black boxes but with knowledge of their inner components. White boxes have an opacity parameter which can be turned on or off individually for each white box through the opacity button:



When the opacity is enabled, the white box will essentially look identical to other black boxes. However when disabled the inner components of the white box will become visible and movable.

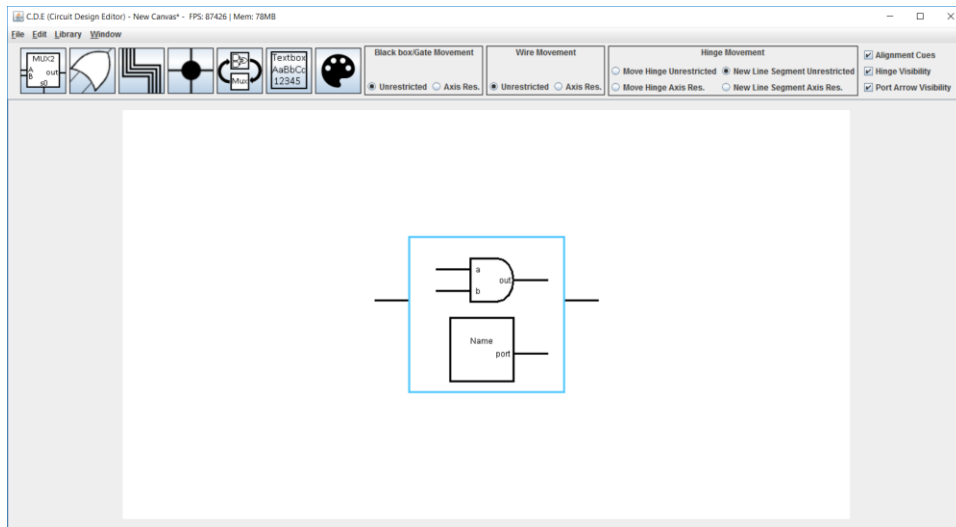
1) To create a White Box, there first needs to be a selection of components active in the canvas. After a selection has been made, when we click on the "Black Box Button", a prompt will ask whether this should be a White Box instead. By clicking yes, we will be taken to a slightly changed specification window:



The White Box specification window should look almost identical to the black box window:

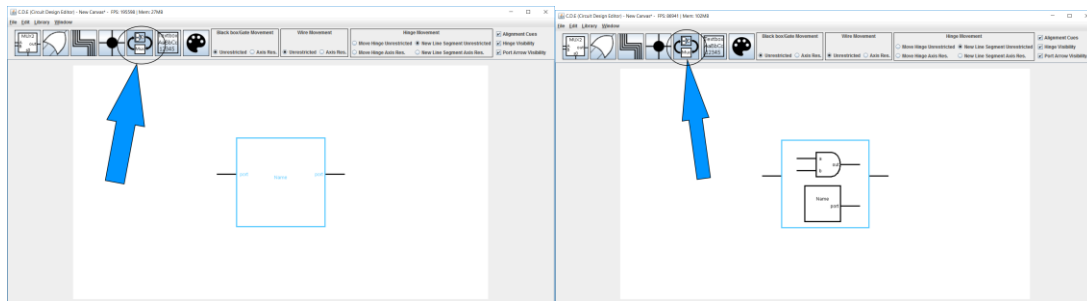
A significant first difference we can observe between the two is that the width and height fields have higher minimum values when compared to a black box. In fact, different selections of components will yield different minimums here, as these minimums are calculated in order to fit all the selected components into the new white box. We can of course increase the dimensions of the white box however we please.

2) By placing some ports and clicking Create Component, the new white box should appear in the center of the canvas with all the inner components inside it:



3) Since the selected components are now children of the white box, they can be individually moved around, without any side effects on the location of the parent white box, but if the white box is moved, all the inner components will be moved by the respective deltas.

4) As explained above, the individual opacity of a white box can be toggled on and off through the White box opacity button. When opaque the white box will behave exactly like a black box does in the canvas area.

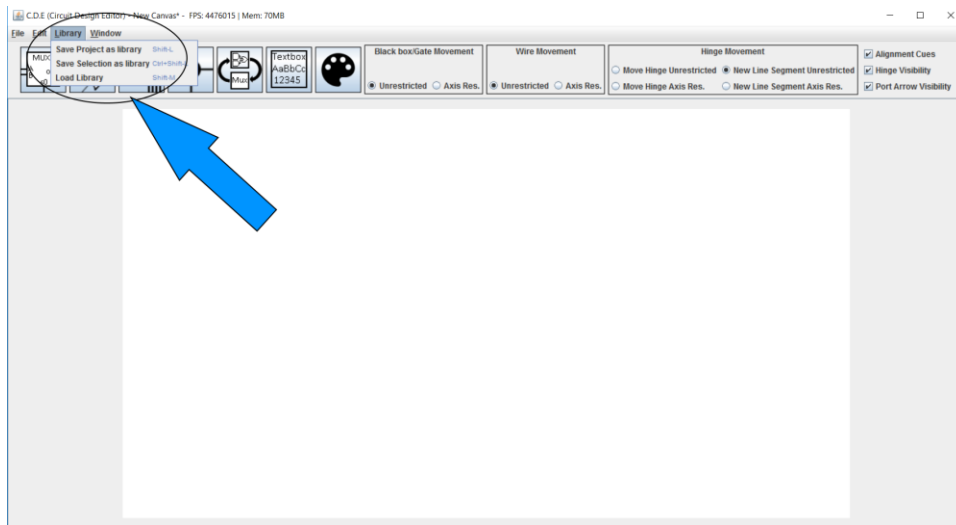


Practice Exercise: Create 2 white boxes each containing a ripple 4 carry adder circuit

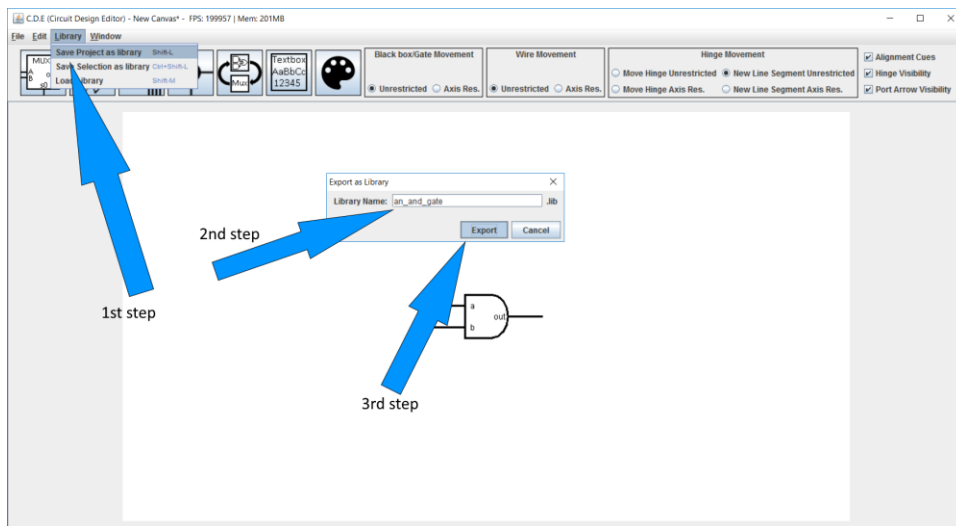
Libraries

It is very common in circuit design that some custom components are very frequently used in many different places. Hence the need for a mechanism to quickly save and retrieve these commonly used components lead to the addition of libraries. A library can be constructed from a single gate to a big white box, to a large selection of components. All libraries are saved in a central repository inside the Circuit Design Editor's directory located in the home directory of the user.

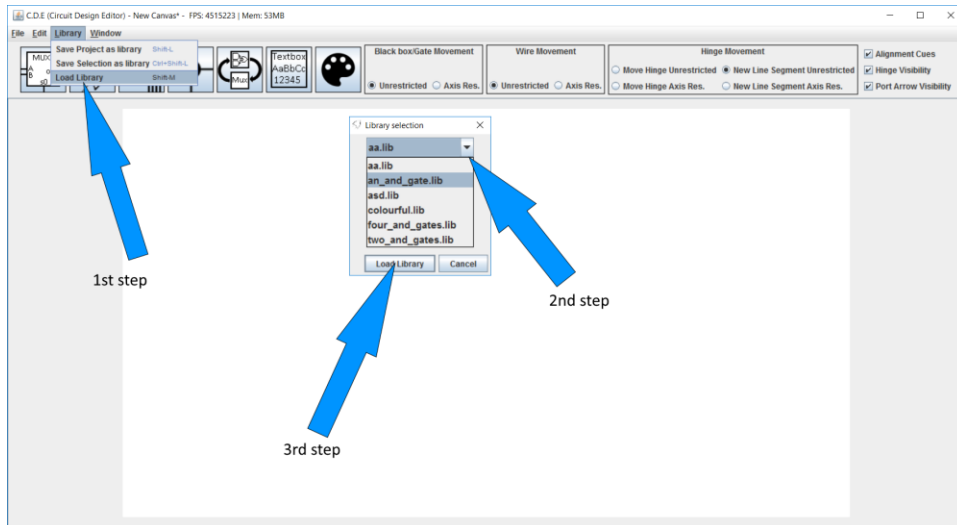
1) All library related actions live under the Library Menu tab:



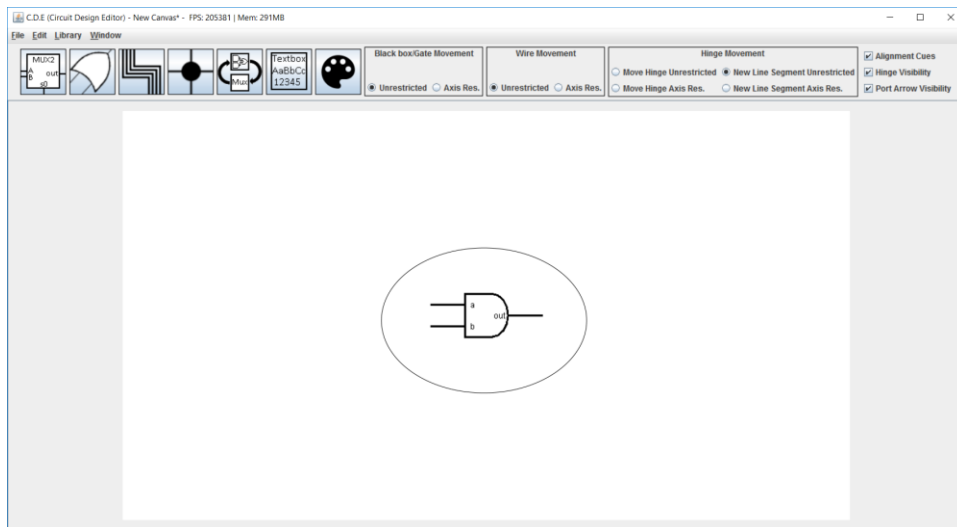
2) To create a library we can either select a number of components (to use the Save Selection as Library option) or use all of the components in the canvas automatically (Save Project as Library). A prompt will then ask for the desired library name and by clicking "Export" the library will be created:



3) In order to load a library all we have to do is click on the "Load library" option under the "Library" menu tab. We can then select the desired library from the list of libraries in the repository, and then finally click the "Load Library" button.



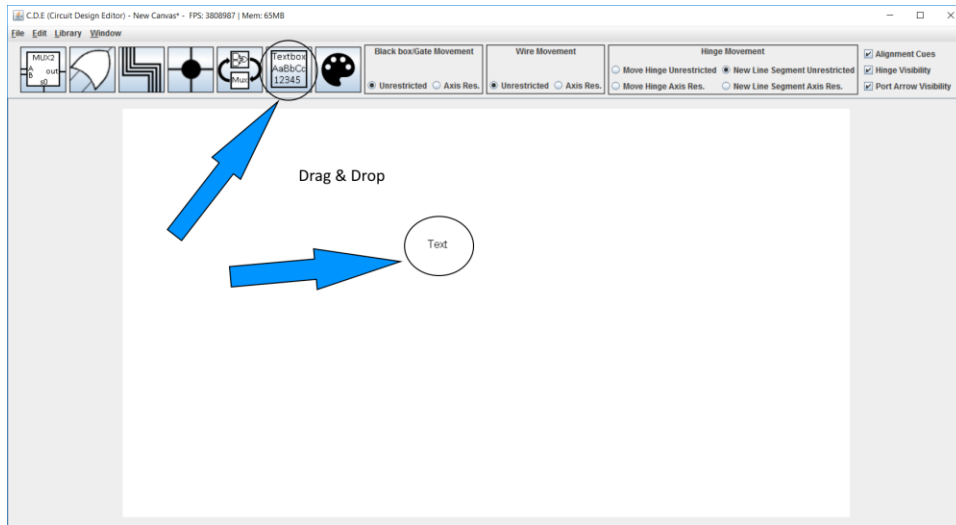
We can now observe that the library was loaded successfully in the canvas.



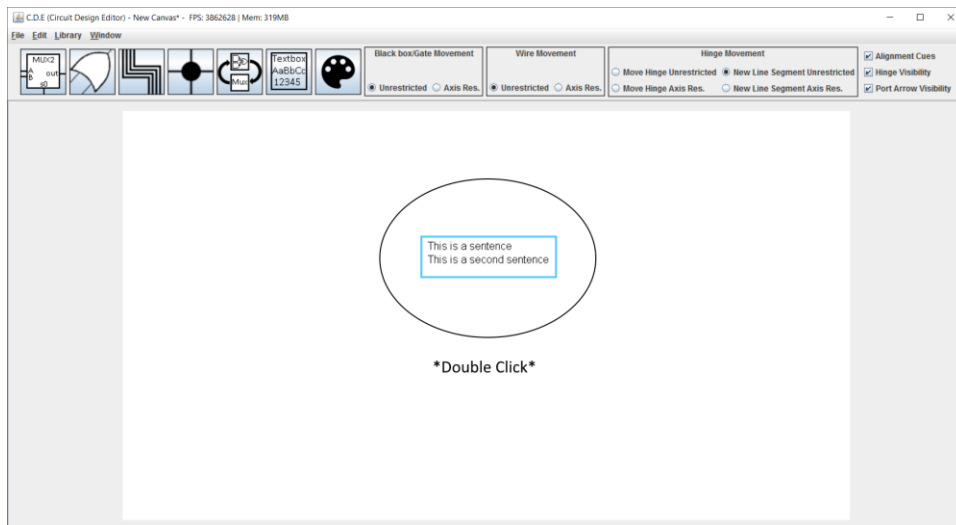
Meta notation utilities

Alongside the actual system, meta notation utilities such as text boxes and custom component coloring can greatly enhance the readability of a diagram.

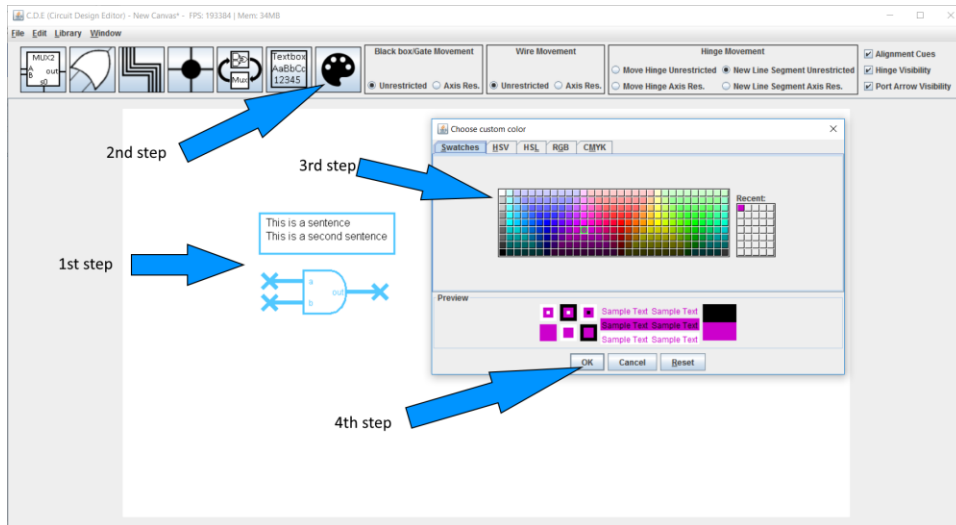
1) Text boxes can be created by dragging and dropping from the "Textbox Button" (5th leftmost button in the Tool's panel) to the desired location:



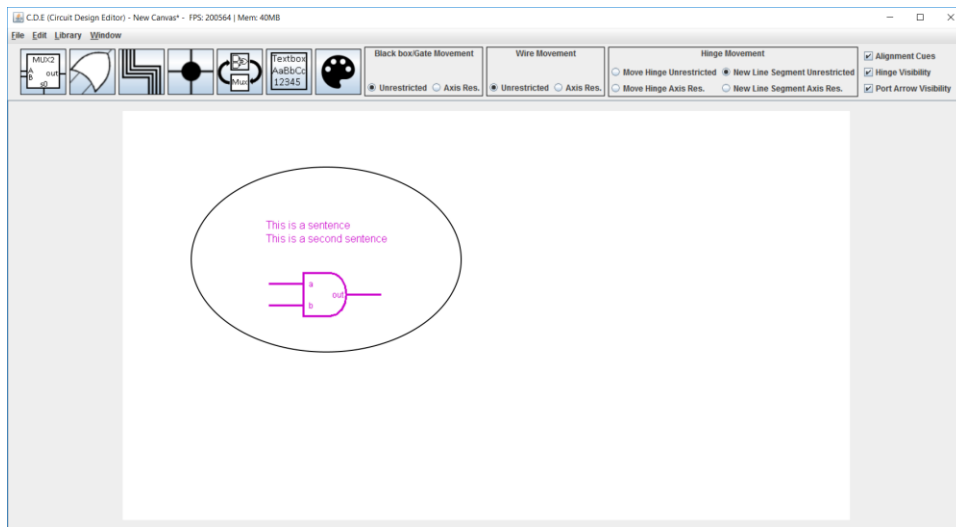
2) We can edit the textbox's inner text by double clicking the textbox and disabling input by clicking anywhere else or just moving the component:



3) There is also the option to custom color a selection of components by selecting a group of objects and clicking on the palette button (6th leftmost button). In the next prompt the desired color can be specified:



By clicking OK, the selected components will now be colored accordingly.



Practice Exercise: Create two differently colored textboxes and white-box them

Misc Options and Common Editing Actions

There are also a few miscellaneous options that can be accessed either from the menu or the tool's panel:

- Global Alignment can be switched on and off from the respective checkbox at the right side of the tools panel.
- Hinge Visibility and port arrow visibility can be likewise switched on and off from the Hinge Visibility checkbox at the right side of the tools panel.
- The layout (design) of the window can be changed to various other themes by using the Window->Change Look & Feel action

- Alongside these tools, all common editing actions are supported such as new canvas, canvas resizing, undo, redo, copy, paste and select all, zooming and others, all of which can be accessed from the File and Edit tabs in the menu, as well as with their keybindings which are displayed in the next section

Keybinding List

CTRL+N	New Canvas
CTRL+O	Open Project
CTRL+S	Save Project
CTRL+SHIFT+S	Save Project to Location
CTRL+R	Resize Canvas
CTRL+E	Export Project to SVG
CTRL+Z	Undo
CTRL+Y	Redo
CTRL+A	Select all components
CTRL+C	Copy
CTRL+V	Paste
DELETE	Delete
SHIFT+W	Create White box from selection
SHIFT+O	Toggle Opacity of Whitebox
SHIFT+L	Save project as Library
CTRL+SHIFT+L	Save selection as Library
SHIFT+M	Load Library
CTRL+ -	Zoom out (by a fixed amount)
CTRL+ =	Zoom in (by a fixed amount)
CTRL+Mouse Wheel (away from user)	Zoom in freely
CTRL+Mouse Wheel (towards user)	Zoom out freely