

# RoutePlotter User Guide

*Win 2000/XP/Vista Deployment*  
*v.2007.09.13*

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## WHAT IS ROUTEPLOTTER?

RoutePlotter is a MS Excel add-in for visualization and analysis of vehicle routes.

## WHAT CAN YOU DO WITH ROUTEPLOTTER?

- Visualization:
  - Plot vehicle routes on MS Excel using a scatter plot
  - Display and hide selected routes interactively
- Export graphics:
  - Export the routes as a gif file
  - Generate the TeX code required to plot routes using LaTeX via [gnuplot](#).
  - Build the batch and data files required to plot routes using [gnuplot](#).
- Manipulation and analysis:
  - Calculate length (Euclidean) and load for each route
  - Exchange selected nodes between routes
  - Insert nodes into routes
  - Alter the sequence of the nodes within a route

## LICENSE

You are free to use RoutePlotter for academic or research use. For commercial use, please contact the authors. If you use RoutePlotter in your research, please give proper credit to the authors by citing the following work:

J. E. Mendoza, A. L. Medaglia and N. M. Velasco.

RoutePlotter: a spreadsheet based visualization and analysis tool for vehicle routing. Working Paper, COPA 2007-2. Universidad de los Andes. 2007.

Available at: <http://hdl.handle.net/1992/1051>

## REQUIREMENTS

The requirements for RoutePlotter are:

- Operating system: MS Windows XP or later
- MS Office: MS Office 2000 or later
- Visual Basic: Visual Basic for Applications 6.3 or later
- gnuplot: version 4.2 available for download at <http://www.gnuplot.info/>

## FILES IN DISTRIBUTION

After expanding the distribution file `RoutePlotter-YYYYMMDD.zip`<sup>1</sup> in the target directory, you will have the folder structure described on Table 1.

Table 1: Folder structure

Folder	Description	Typical Value
<code>RoutePlotter-YYYYMMDD</code>	Target folder. Throughout this document we use the alias of <code>[target]</code> for this folder.	<code>c:\RoutePlotter-20070913</code>
<code>[target]\examples</code>	Folder where the example files reside.	<code>c:\RoutePlotter-20070913\examples</code>
<code>[target]\doc</code>	Folder with documentation such as user guides.	<code>c:\RoutePlotter-20070913\doc</code>

## HOW TO INSTALL ROUTE PLOTTER

After expanding the distribution file `RoutePlotter-YYYYMMDD.zip` in the target directory follow the next steps to install RoutePlotter.

- Open MS Excel
- Select **Add-Ins** from the **Tools** menu of the main menu bar. Alternatively, in Vista, click on the Office button , then on **Excel options**.
- Click on **Browse** to search for the **RoutePlotter** file
- Select the file `routePlotter-YYYYMMDD.xla` from folder `[target]`
- Click on **Ok** to continue with the installation procedure
- Click on **Continue Installation** on the welcome screen shown in Figure 1.

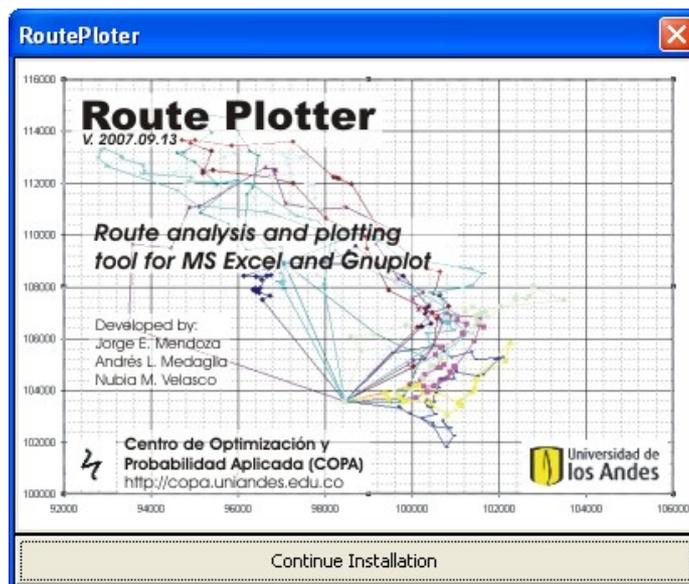


Figure 1: RoutePlotter welcome screen

<sup>1</sup> Where YYYY stands for the year, MM stands for the month, and DD stands for the day of the version of RoutePlotter.

After **RoutePlotter** has been installed on your system, the application would offer you the possibility to register a [gnuplot](#) installation. To do so, follow the next steps:

- Answer **Yes** to the question “Do you want to register a gnuplot installation?”
- Browse the executable file of your [gnuplot](#) installation on your file system. For [gnuplot 4.2](#) the corresponding file is `wgnuplot.exe` located at folder `.\gnuplot\bin`
- Click on **Ok** to finish with the [gnuplot](#) registration procedure

## LICENSE ACTIVATION

Before start using **RoutePlotter**, you must activate your license. To do so, click on **Activate License** on the **RoutePlotter** tool bar. The button will disappear upon the first use of the application.

After you activate your license, **RoutePlotter** will run on your system for one year. After this period, you must uninstall the application, perform a new download, and reinstall the application on your system. This mechanism was adopted to encourage users to adopt the latest available version of **RoutePlotter**.

## HOW TO USE ROUTEPLOTTER?

### 1) PLOTTING VEHICLE ROUTES

To visualize vehicle routes on a MS Excel scatter plot, the input data must be provided with the following structure:

Column 1: Route Id (Integer/String)  
Column 2: Node Id (Integer/String)  
Column 3: X Coordinate (Double)  
Column 4: Y Coordinate (Double)  
Column 5: Demand (Double)

In addition, RoutePlotter expects you have followed these rules:

- For each route, the first and last rows must contain the information of the depot where the tour starts and ends. Open routes (different start and end nodes) are allowed.
- The demand at each depot node must be equal to 0
- The client nodes located in the rows between the starting and ending point must appear in the order in which they are visited by the route
- These columns (1 thru 5) must be adjacent and hidden columns are not accepted.

Let us consider an example with the data shown in Table 2, which corresponds to data on the Example Data Set 1, available on worksheet **ExampleDataSet1** in file `exampleData.xls` located at folder `[target]\examples`.

Table 2: Example Data Set 1

Route ID	Node ID	Cx	Cy	Demand
287	Depot 1	98448.671	103586.499	0
287	5	100488.025	105694.548	3
287	2	100699.033	105657.802	7
287	6	99977.453	104027.158	2
287	12	100202.921	102947.737	4
287	15	99655.878	103384.992	9
287	14	99692.098	103321.067	1
287	13	99908.530	103122.979	1
287	Depot 1	98448.671	103586.499	0
18	Depot 1	98448.671	103586.499	0
18	7	100270.349	104144.451	1
18	9	100523.542	103905.314	4
18	8	100361.481	103954.409	6
18	10	100553.513	103940.840	2
18	Depot 1	98448.671	103586.499	0
339	Depot 2	100870.411	105284.049	0
339	1	100779.937	105588.981	1
339	3	100578.947	105662.367	5
339	4	100488.025	105694.548	2
339	Depot 2	100870.411	105284.049	0
345	Depot 1	98448.671	103586.499	0
345	11	100187.964	102941.963	2
345	18	95428.555	112511.274	3
345	16	95673.563	112990.736	8
345	19	95386.962	113238.955	2
345	17	95858.761	113454.074	5
345	Depot 2	100870.411	105284.049	0

The data shown in Table 2 contains the information of four routes. First, routes 287 and 18 start and end at Depot 1. The first route visits nodes 5, 2, 6, 12, 15, 14 and 13, while the second route visits nodes 7, 9, 8, 10. Second, Route 339 starts and ends on a different depot Depot 2, visiting nodes 1, 3, 4. Third and finally, Route 345 starts on Depot 1 and ends its tour on Depot 2, after visiting nodes 11, 18, 16, 19 and 17; on an open vehicle routing scheme.

To visualize the routes, select the data input (without column titles) and click on **Plot Routes** on the **RoutePlotter** tool bar (or in the Add-ins menu in Vista). When using the Example Data Set 1, the form shown in Figure 2 will appear on your screen. This form is comprised of the following elements:

- 1) Route Information Box
- 2) Action buttons
- 3) Exporting options

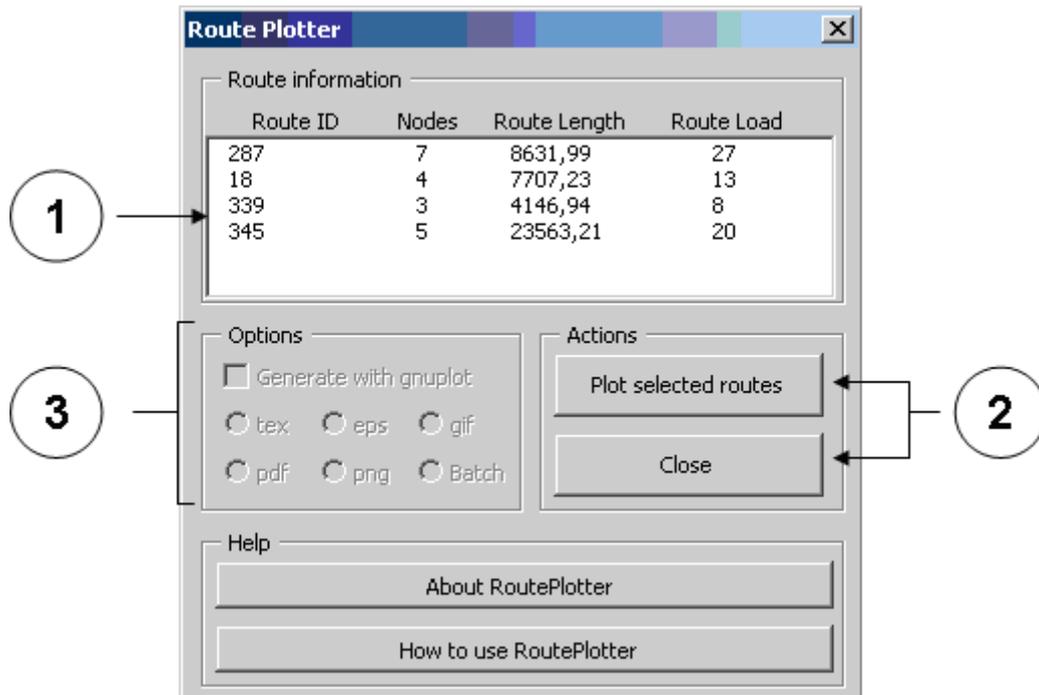


Figure 2: Plot routes form

The **Route Information Box** (see bubble 1 in Figure 2) presents the following information fields for each route:

- Route ID: identifier of each route
- Nodes: number of nodes in the route
- Route Length: total Euclidean distance covered by the route
- Route Load: total demand attended by the route

Select the routes to be plotted from the **Route Information Box** (bubble 1 on Figure 2) and click on **Plot selected routes** on the action buttons (bubble 2 on Figure 2) to continue. For multiple selections, use the `Ctrl` key. Figure 3 shows the results after selecting the four routes in our example.

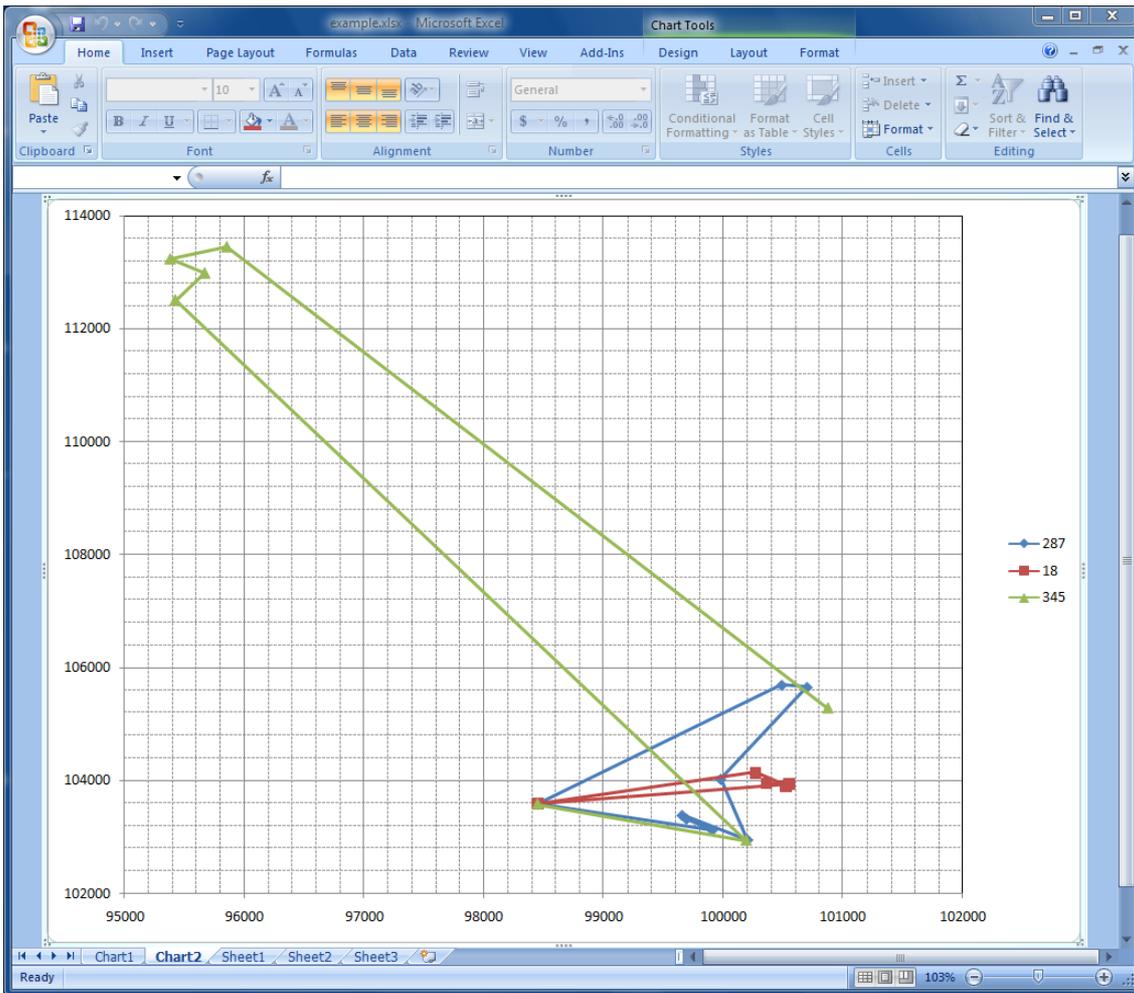


Figure 3: RoutePlotter output for example data set 1 (in MS Vista)

## 2) EXPORTING VEHICLE ROUTES FROM ROUTEPLLOTTER

By registering [gnuplot](#) during the installation of RoutePlotter, it is possible to export the routes using the following output formats:

- **tex**: generates a TeX file with the code required to plot the routes using LaTeX
- **gif**: generates a bitmap to be included on most documents, such as MS Word or even LaTeX files
- **Batch**: generates a batch file with [gnuplot](#) commands and the corresponding data file, to create the graphic using [gnuplot](#)
- **pdf\***: generates a portable document file
- **png\***: generates a Portable Network Graphics bitmapped file
- **eps\***: generates an encapsulated postscript file

\* These options will be available in the near future.

To export the routes, check the option box **Generate with gnuplot** on the **Exporting options** (bubble 3 in Figure 2) and select your exporting preference before clicking on the **Plot selected routes** action button.

The video in file `Exercise1.avi` (available at folder `[target]\examples`) presents how to plot the routes for the Example Data Set 2 (available on worksheet `ExampleDataSet2` in file `exampleData.xls`). The output is shown in Figure 4.

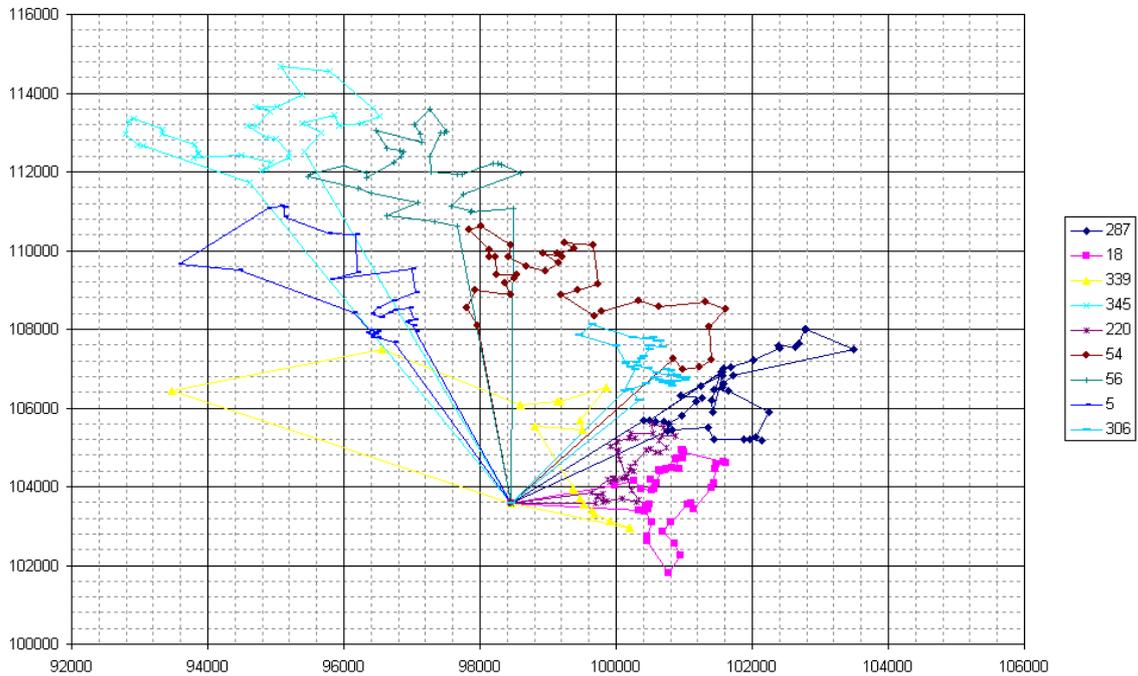


Figure 4: Plotting of routes on the Example Data Set 2

### 3) ANALYZING AND HANDLING ROUTES

#### Visualization tools

To interactively change the way routes are displayed, click on **Analysis Tools** on the **RoutePlotter** toolbar and then on the **Visualization** tab to activate the form shown in Figure 5. The **Visualization** tab is comprised of the following elements:

- 1) Route information box
- 2) Plotted solution summary box
- 3) Worksheet information
- 4) Action buttons

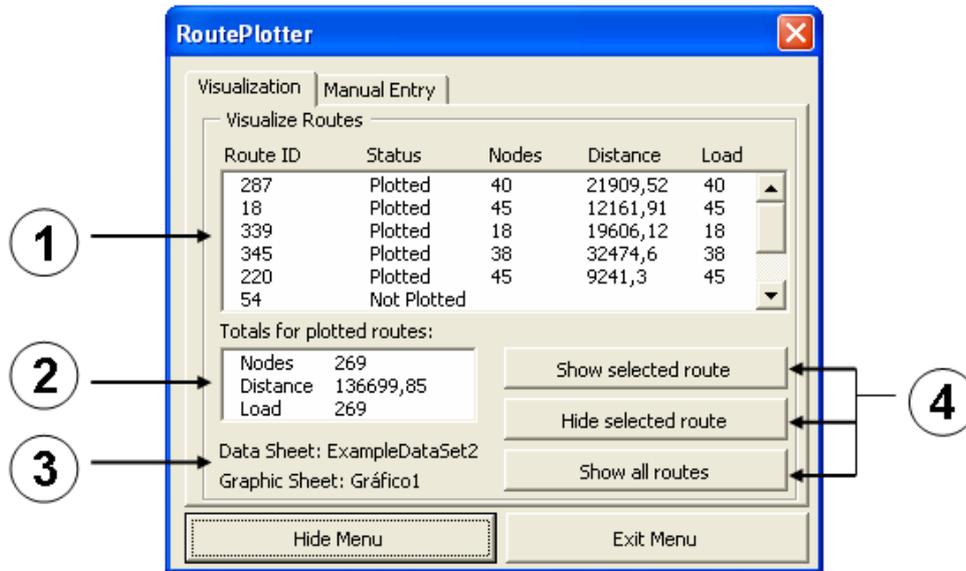


Figure 5: Visualization tools tab

The route information box (bubble 1 in Figure 5) presents the information of each route. The plotted solution summary box (bubble 2 in Figure 5), presents a summary of the performance metrics only for the plotted routes (that is, those routes with status = plotted). The worksheet information labels (bubble 3 on Figure 5) show the information regarding the worksheet from where the data has been loaded and the worksheet where the output graph is stored. The Action buttons (bubble 4 in Figure 5), allow the user to hide or show routes. A hidden route has status of *Not Plotted*, but the underlying data remains loaded ready to be shown again. The file `Exercise2.avi` shows an example of how to hide a route and then show it back; and how to hide three different routes and show them back again using the **Show all routes** button.

Note that there are two buttons at the bottom of the panel in Figure 5 that close the **Analysis Tools** form. While the button **Hide Menu** simply hides the menu to allow the user a full view of the plotted routes, it does not unload the data of the plotted routes. On the other hand, the button **Exit Menu** not only hides the form but also unloads the data. After leaving the menu with the **Exit Menu** button, it is not possible to continue with the interactive analysis.

### Route handling tools

Often a user needs to revise the routes generated by a routing algorithm. Some node exchanges and route modifications are needed to further accommodate some business rules, possibly not taken care by the algorithm, or simply to postoptimize an algorithm's output. To handle the plotted routes, click on **Analysis Tools** on the **RoutePlotter** toolbar and select the **Manual Entry** page to activate the form shown in Figure 6. The panel in Figure 6 contains the following elements:

- 1) Route selection boxes
- 2) Node selection boxes
- 3) Route information boxes
- 4) Node exchange button
- 5) Node extraction/insertion buttons

## 6) Node moving buttons

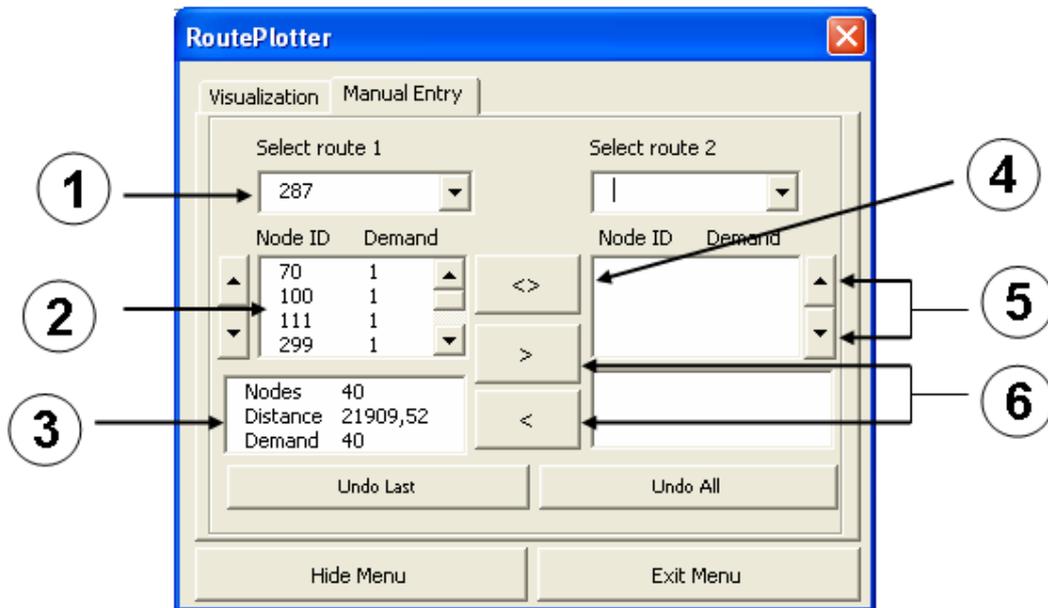


Figure 6: Manipulation tools form

Three different types of route handling operations are allowed by **RoutePlotter**. These operations are explained below.

### A) Node exchange between routes

To exchange nodes between routes follow the next steps:

- Select two routes, namely Route 1 and Route 2, using the route selection boxes (bubble 1 in Figure 6)
- Select a node from Route 1 and a node from Route 2 using the corresponding node selection box (bubble 2 in Figure 6) for each route. The selected node corresponds to the highlighted node on the graphic.
- Click on button  (bubble 4 in Figure 6) to exchange the two selected nodes

File `Exercise3.avi` shows the exchange of node 291 on Route 18 and node 143 on Route 220.

Note that when a node is selected the arc containing the node is activated on the graph. The node to be exchanged is the head node of the activate arc.

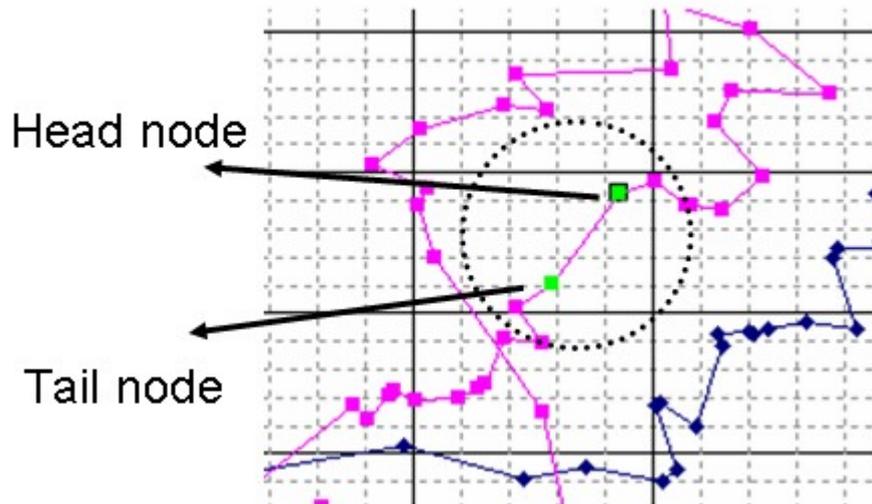


Figure 7: Active arc and node

### B) Moving one node between routes

To extract a selected node from one route and insert it into another route, the user of **RoutePlotter** should follow these steps:

- Select the source route from where the node will be extracted using one of the route selection boxes (bubble 1 in Figure 6)
- Select a node to be extracted from the source route using the node selection box (bubble 2 in Figure 6)
- Select a destination route to insert the node using the right route selection box
- Choose the arc in which the node will be inserted
- Click on  (bubble 6 in Figure 6) to insert a selected node from Route 1 into an activate arc of Route 2 and  (bubble 6 in Figure 5) to perform the opposite operation

File `Exercise4.avi` shows the extraction of node 337 from Route 339 and its insertion on the arc connecting nodes 140 and 35 in Route 54, followed by the extraction of node 345 from route 339 and its insertion into the recently created arc connecting nodes 140 and 337.

### C) Alter the order of a node on its current route

To move a node back and forth from its current position in a route, follow the next steps:

- Select the route that currently contains the node to be moved using one of the route selection boxes
- Select the node to be moved on the node selection box of the corresponding route
- Click on  (bubble 5 in Figure 6) to move the node backwards from its current position
- Click on  (bubble 5 in Figure 6) to move the node forward from its current position

File `Exercise5.avi` shows how node 253 is moved one position forward from its current position on Route 54, generating a saving on the total length of the route.

The saving is calculated as follows:

$$S = (D_{1,B} + D_{2,B}) - (D_{1,A} + D_{2,A})$$

Where  $D_{1,B}$  and  $D_{2,B}$  denote the values of the total distance of routes 1 and 2 (left and right) right before a movement is performed by the user, and  $D_{1,A}$  and  $D_{2,A}$  the values after completing the handling operation. If the value of  $S$  is positive, the new routes improve the previous solution and the saving is reported.

## CONTACT INFORMATION

For further technical information or to report any problem related to RoutePlotter, please contact the developer:

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