CSIS Discussion Paper No.81

User Reference for SANET:

A Toolbox for Spatial Analysis on a Network

September, 2006

Shino Shiode*, Kei-ichi Okunuki** and Atsuyuki Okabe*

* Center for Spatial Information Science, University of Tokyo

** Department of Geography, Nagoya University

PREFACE

This manual describes how to use SANET: a toolbox for spatial analysis on a network. SANET is part of the results obtained from the six year (1998-2003) project entitled “Spatial Information Science for Human and Social Sciences” funded by the Grant-In-Aid for Special Field Studies B provided by the Ministry of Education and Science, Japan. The leader is A. Okabe. SANET is developed by A. Okabe, K. Okunuki and S. Shiode with Mathematical Systems Inc.

ACKNOWLEDGEMENTS

We express our thanks to Mathematical Systems Inc, in particular, C. Mizuta, K. Okano, M. Saito and T. Ishitomi, for developing computer programs.

NOTICE

The authors distribute SANET only to those who agree on the following points.

1. The user will use SANET for nonprofit purposes only.

2. The authors will not bear responsibility for any trouble that the user may meet in the use of SANET.

3. When the user uses SANET, he/she will report to the authors his/her name, affiliation, address and e-mail address.

4. When the user publishes any results obtained by using SANET, he/she will explicitly state in the paper that he/she used SANET. Also, he/she will send a reprint of the paper to the authors.

5. The user will report to the authors any trouble he/she meets in the use of SANET. (The authors will remove bugs, if any, at their earliest convenience.)

The address of the authors is:

Atsuyuki OKABE
Center for Spatial Information Science
c/o Department of Urban Engineering, University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
atsu@ua.t.u-tokyo.ac.jp

TABLE OF CONTENS

1. System requirements

OS: MS Windows NT, 2000, XP

ESRI ArcGIS: Ver.8.x, Ver.9.x

2. Installation and uninstallation of SANET

Installation

1. Save SANET3.zip in your computer.
2. Unzip SANET3.zip, then you will find five files below.
   - SANET_tools.dll
   - SANET_AG_8.dll
   - SANET_AG_9.dll
   - Uinstall_AG_8.bat
   - Uinstall_AG_9.bat
3. Place SANET_tools.dll under arcgis¥Bin folder.
4. Place the other files under any folder.
5. Launch ArcMap.
6. In the ArcMap menu bar, select “Tools” and proceed to “Customize”.
7. Click on “Add from file…” button in “Toolbars” tag, to locate SANET_AG_8.dll or SANET_AG_9.dll.
   (If you are ArcGIS Ver.8 user, load SANET_AG_8.dll.)
   (If you are ArcGIS Ver.9 user, load SANET_AG_9.dll.)
8. Double click on it, then you will find “SANET” check box in “Toolbars” menu.
9. Check it, then the SANET menu bar below will appear.

10. Drag and drop it in your menu bar or view button bar on the ArcMap project window.

Uninstallation

If you are ArcGIS Ver.8 user, click Uinstall_AG_8.bat.

If you are ArcGIS Ver.9 user, click Uinstall_AG_9.bat.

3. General notes on SANET tools

SANET consists of twenty tools, each of which belongs to one of three groups, **ShapeEditor**, **NetworkIndex**, and **Analysis,** divided by their function.

Analytical tools in “Analysis” group should be executed after applying some preprocessing tools.
When you are going to apply one tool, be sure to apply all the tools located upstream in the illustration below.

Preprocessing and analytical tools

Preprocessing tools

Clean polyline shapes
↓
Continuous graph
↓
Create network index file from a polyline shapefile
↓
Insert points to a network
↓

Analytical tools

Voronoi diagram
Huff model
Nearest neighbor distance method
Conditional nearest neighbor distance method
K function method
Cross K function method
Interpolation
Clumping method
M function method

Other independent tools

Random point
Polygon centroid
Grid
Distribute point data to polylines
Table arrangement
Create network index file from adjacent node table
Edit network index file

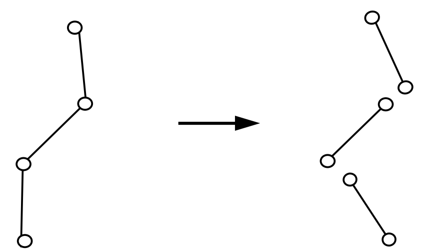
4. Instructions on how to use SANET

4.1 Preprocessing tools

4.1.1 Clean polyline shapes

Polyline shapefiles introduced in SANET have to be free of intermediate or pseudo points.

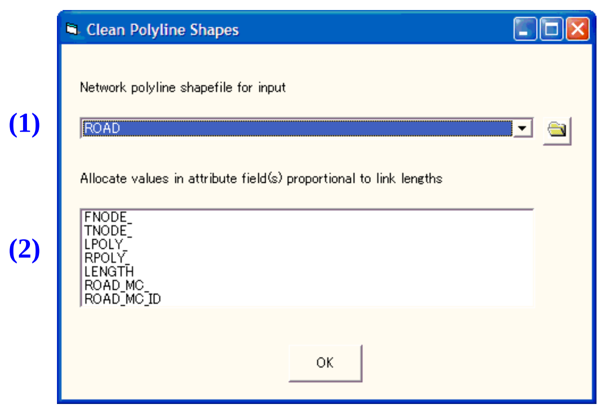
This tool cuts a polyline into individual line segments or links. Each of them consists of a line and two end points.



(a) A polyline (b) Individual links

Inputs

1. Add the polyline shapefile on the project window.
2. Select "Clean Polyline Shapes" in **ShapeEditor** menu.



3. Fill in the dialogue box.
   (1) Select the polyline shapefile in the drop down list.
   (2) All the attribute fields in the polyline shapefile are listed in this box. If you want to get values in the attribute field(s) to be split proportional to link lengths, select them.

Output

A polyline shapefile named "*polyline shapefile* *_d*" will be created in the folder where the input shapefile is located.

Although the entire attribute field(s) in the original network polyline will be attached to the output network polyline, fields you did not select at step **(2)** will be transferred with no change in values.

In case that a file with the same filename already exists, the newly created file will be saved with a different filename, such as <nework polyline shapefile_d1>, <nework polyline shapefile_d2>.

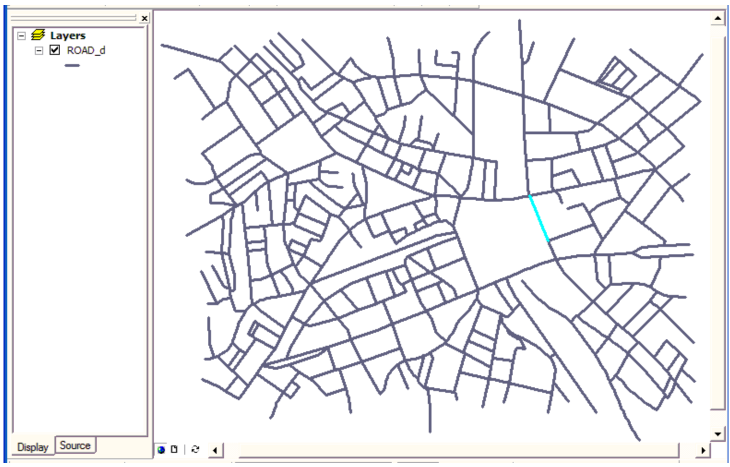
4.1.2 Continuous graph

Since network polylines in one shapefile should be connected to each other in SANET, all the isolated polylines have to be eliminated before proceeding to the next step.

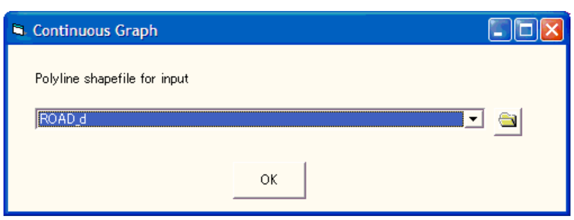
This tool checks up the connectivity of the network and extract the continuous network.

Inputs

1. Add the polyline shapefile on the project window.
2. Select “Continuous Graph” in **ShapeEditor** menu.
3. Click and activate a link which belongs to the network that you want to extract.



4. Select the polyline shapefile in the drop down menu.



Note: As a sample dataset, we here use network polyline shapefile named “ROAD_d” consisting of 1367 links and 33km of total length.

Output

A network polyline shapefile of the continuous graph will be created (filename: *network index file name* _prt**)**.

4.1.3 Create network index file from a polyline shapefile

This tool converts a polyline shapefile into a dataset which consists of the following three files to identify the link-node connectivity.

(1) Polyline point shapefile

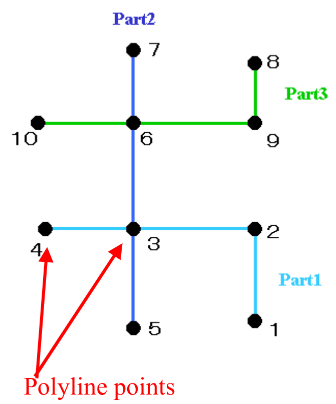
A point shapefile created by extracting the entire points that consist a polyline shapefile, which we call “polyline points”. The attribute table of the polyline point shapefile has a field with pointer values pointing the record number of the adjacent node table.

(2) Adjacent node table

A DBF format table with the fields of the adjacent node ID, the link length and any other attributes field(s).

(3) Network index file

A text file which holds the filenames of (i) the input network polyline shapefile, (ii) the output polyline point shapefile and (iii) the output adjacent node table.



Polyline parts and polyline points

Pointer

NodeID	head	x	y
1	1	…	…
2	2		
3	4		
4	8		
5	9		
6	10		
7	14		
8	15		
9	16		
10	18		

Attribute table of polyline point shapefile

Adjacent node ID

Link length

Record number

	AdjPoint	Length
1	2	…
2	1	
3	3	
4	2	
5	4	
6	5	
7	6	
8	3	
9	3	
10	3	
11	7	
12	9	
13	10	
14	6	
15	9	
16	8	
17	6	
18	6	

Adjacent node table

Inputs

1. Add the polyline shapefile on the project window.

Network polyline shapefile “ROAD_d

2. Select “Create Network Index File from Polyline Shapes” in **NetworkIndex** menu.

3. Fill in the dialogue box.

(1) Select the polyline shapefile in the drop down menu.

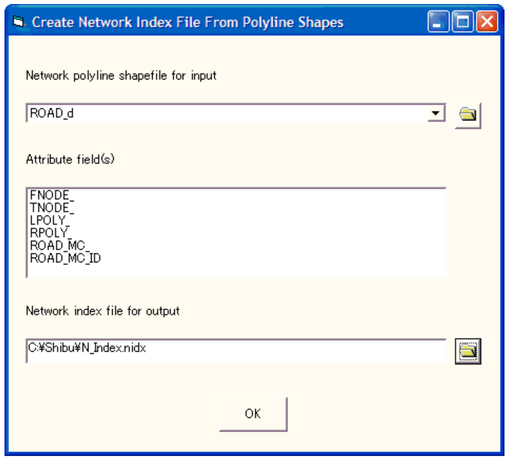
(2) If you want to transfer the attribute field(s) in the network polyline to the adjacent node table, select them.

(3) Specify the filename and the location of the output network index file by clicking  button.

(1)

(2)

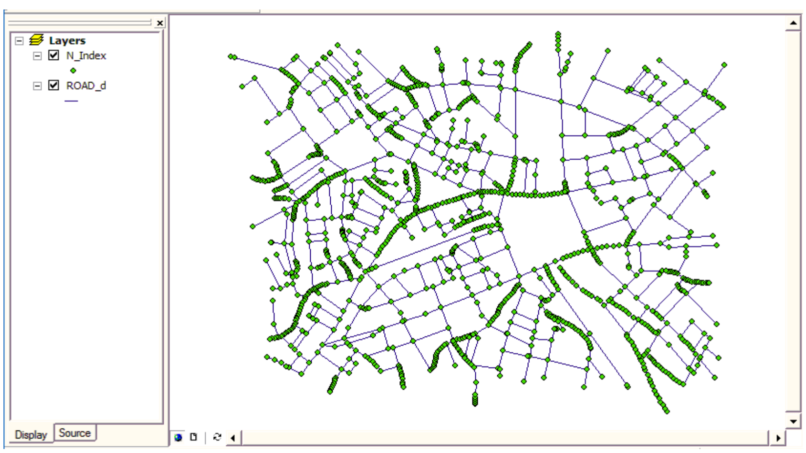
(3)



<u>Outputs</u>

(1) Polyline point shapefile (filename: *<u>network index file name</u>* **).**

A point shapefile which consists of the entire polyline points will be created.



Polyline point shapefile “N_Index”

Attribute fields of the polyline point shapefile.

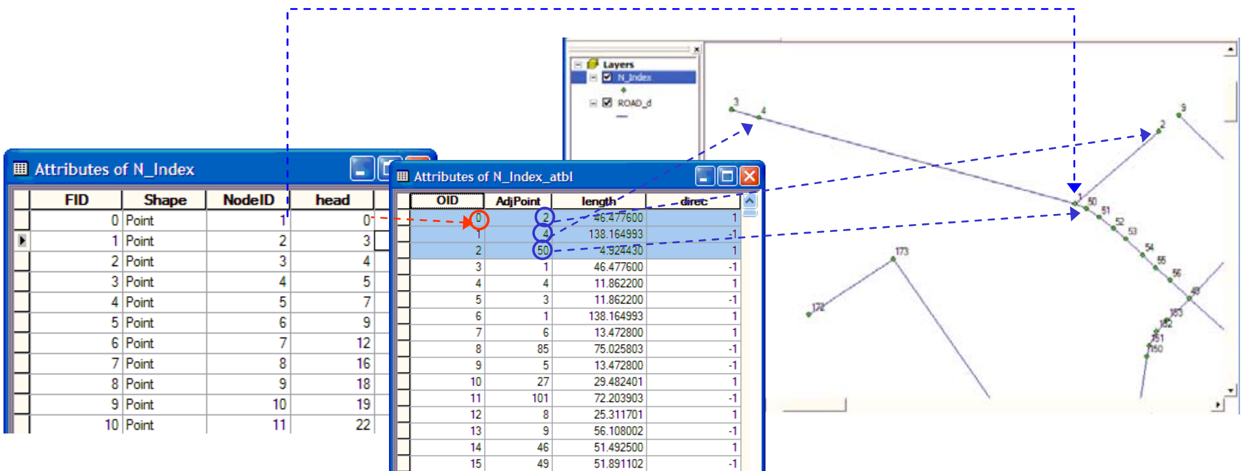
FID	Record number.
NodeID	ID number of the polyline point.
head	Pointer to the record number of the adjacent node table, which is stored in the field “OID”.
X	X Coordinate.
Y	Y Coordinate.

(2) Adjacent node table (filename: _network index file name_ _atbl.dbf).

OID	Record number.
AdjPoint	ID number of the adjacent node.
Length	Link length between two polyline points, one of which is in the attribute table of the polyline point shapefile and the other is in the adjacent node table.
direc	Direction of the link. 1: forward, -1: backward.
Attribute field(s) selected at step **(2)**.	

Note: We will omit fields “FID” and “OID” for the subsequent text, as they always hold the record numbers.

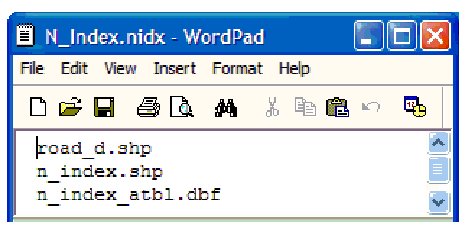
Note: If the field “LENGTH” and/or “ADJPOINT” existed in the fields you selected at step (2), they will be saved in a different name such as “LENG_1” and “ADJ_1” respectively.



Attribute table of the polyline Shapefile “N_Index”

Adjacent node table “N_Index_atbl.dbf”

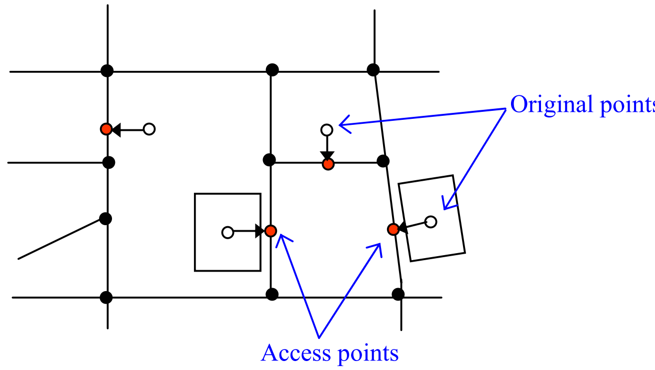
(3) Network index file (filename: network Index file name .nidx).



4.1.4 Insert points to a network

This tool assigns a point which is not on a network (we call it "**an original point**") to the nearest point on a network (we call it "**an access point**").

Applying this tool, polylines are cut at the access points and access points become new polyline points.



Inputs

1. Add the following shapefiles on the project window.

   (1) Network polyline shapefile.

   (2) Original point shapefile.

Polyline shapefile "ROAD_d" and point shapefile "BANK_STORE"

2. Select "Insert Points to Network" in **NetworkIndex** menu.

3. Fill in the dialogue box.

(1) Specify the network index file outputted in the previous tool.

Note: By clicking icon, you can see the contents of the network index file.

(2) If you want to get values in the attribute field(s) of the polyline to be split proportional to link lengths, select them.

(3) If you want to get values in the attribute field(s) of the adjacent node table to be split proportional to link lengths, select them.

(4) Select the original point shapefile in the drop down menu.

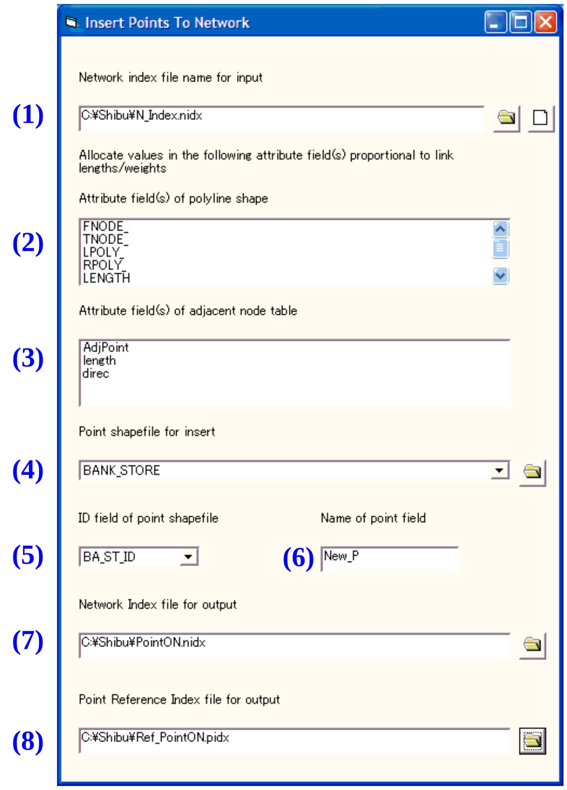
(5) Select the field of the ID number in the original point shapefile.

Note: The ID number will be reflected in "point access table" (see output files in detail) for the correspondence between the original points and the new polyline points.

(6) Specify a new field name for the identification of the access points (The filename should be less than ten characters).

(7) Specify the filename of the network index file.

(8) Specify the filename of the point reference index file.



Outputs

(1) Network polyline shapefile (file name: *Network Index file*).

All the attribute field(s) in the original polyline shapefile will be attached to the output polyline. Fields you did not select at step **(2)** will be transferred without any change in values. Field "direc" with the link direction will also be added.

(2) Polyline point shapefile (file name: *Network Index file* _v).

Point shapefile consisting of the existing polyline points and the access points.

NodeID	ID number of the polyline point.
X	X coordinate.
Y	Y coordinate.
head	Pointer to "the adjacent node table".
rhead	Pointer to "the point reference table".
Number	Number of the assigned original points.
(6)	1: inserted point, 0: existing point.

(3) Point access table (file name: *Point Reference Index file* _r.dbf).

File showing the ID correspondence between the original points and the new polyline points.

PointID	ID numbers of the original points stored in the field you selected at step **(5)**.
NodeID	Corresponding polyline point ID in the new polyline point shapefile.

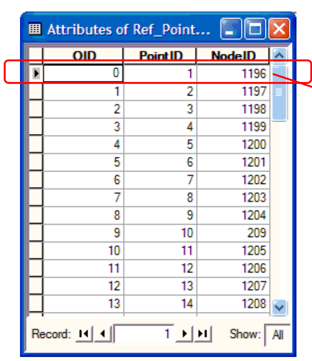
(4) Adjacent node table (filename: *network index file* .atbl.dbf).

AdjPoint	ID number of the adjacent node.
Length	Link length between two polyline points, one of which is in the attribute table of the polyline point shapefile and the other is in the adjacent node table.
direc	Direction of the link.
	All the attribute fields in the input adjacent node table. Values in the field(s) you selected at step **(3)** are split proportional to the link length.

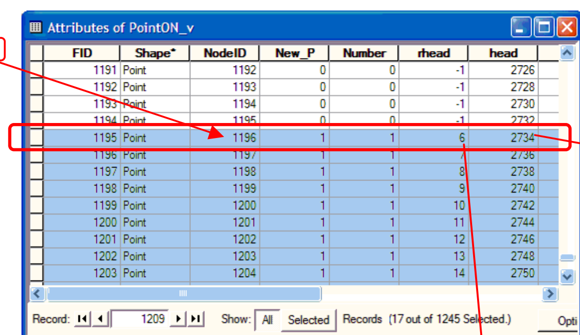
Note: If fields "AdjPoint", "Length" or "direc" existed in the field you selected at step **(3)**, they will be saved with the names of "AdjP_1" , "leng_1" and "dire_1" respectively. Similarly, if a field "LENG_1" and/or "ADJP_1" were in the fields you selected, they will be saved with the names of "LENG_2" and "ADJP_2" respectively. Since values in those fields are updated in fields "Length" and "Adjpoint" in the new adjacent node table, you do not need to care about values in "LENG_1", "LENG_2", "ADLP_1", "ADJP_2".

(5) Point reference table (filename: *point reference index file*_ref.dbf).

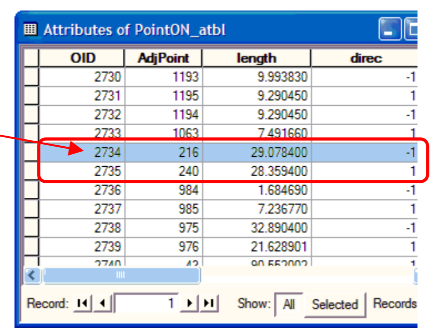
PointID	Point ID of the original point.
InsDirec	Direction where a point was inserted (1: from the left of the link, 2: from the right, 0: on the link).



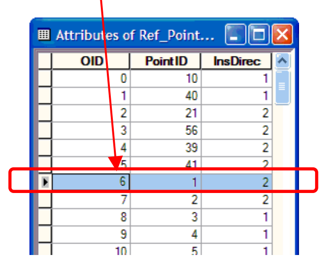
Point access table
"Ref_PointON _r"



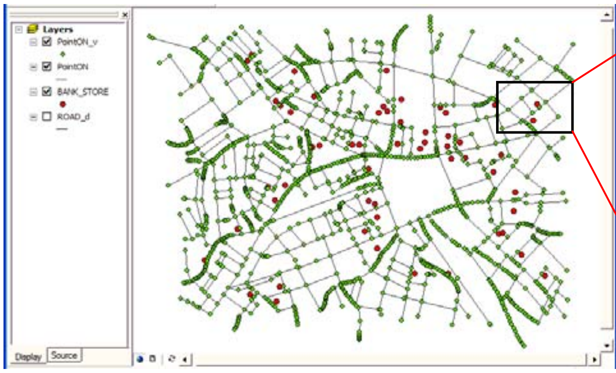
Attributes of the polyline point
shapefile "PointON _v"



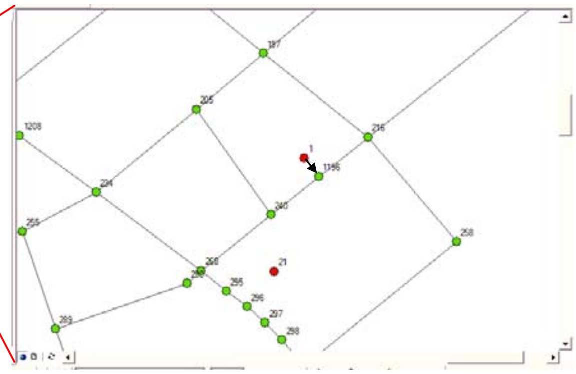
Adjacent node table
"PointON _atbl.dbf"



Point reference table "Ref_PointON _ref"



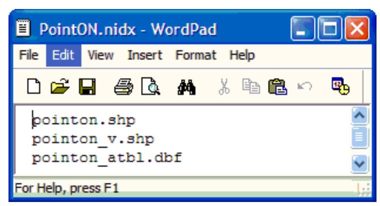
Polyline shapefile "PointON" and polyline point shapefile "PointON _v"



Original points and access points

As is shown in the figures above, the original point with ID number of 1 has become the new polyline point 1196, which is indicated in the field "NodeID". In the attribute table of polyline point shapefile, polyline point 1196 is pointing the record number 2734 of the adjacent node table, which shows the polyline point 1196 is adjacent to two polyline points, 216 and 240. Polyline point 1196 is also pointing the record number 6 of the point reference table, which shows this point corresponds to the original point with ID number of 1 as shown in the field "PointID".

(6) Network index file (filename: <u>*network Index file name*</u> .nidx).



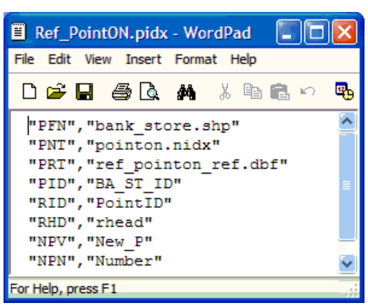
PointON.nidx - WordPad

File Edit View Insert Format Help

```
pointon.shp
pointon_v.shp
pointon_atbl.dbf
```

For Help, press F1

(7) Point reference index table (filename: <u>*point reference index file*</u> .pidx).
A text file with information on the input and the output data set.



Ref_PointON.pidx - WordPad

File Edit View Insert Format Help

```
"PFN","bank_store.shp"
"PNT","pointon.nidx"
"PRT","ref_pointon_ref.dbf"
"PID","BA_ST_ID"
"RID","PointID"
"RHD","rhead"
"NPV","New_P"
"NPN","Number"
```

For Help, press F1

4.2 Analytical tools

As all the point features used in each analytical tool have to be on the network, “Insert points to a network” tool should be applied before executing each analytical tool.

4.2.1 Network Voronoi diagram

This tool constructs a Voronoi diagram on a network based on a set of points denoted by “generator points” or “generators”.

Network shapefile “ROAD_d” and the generator point shapefile “STORE”

Inputs

1. Select “Network Voronoi Diagram” in **Analysis** menu.
2. Fill in the dialogue box.

(1) Specify the network index file.

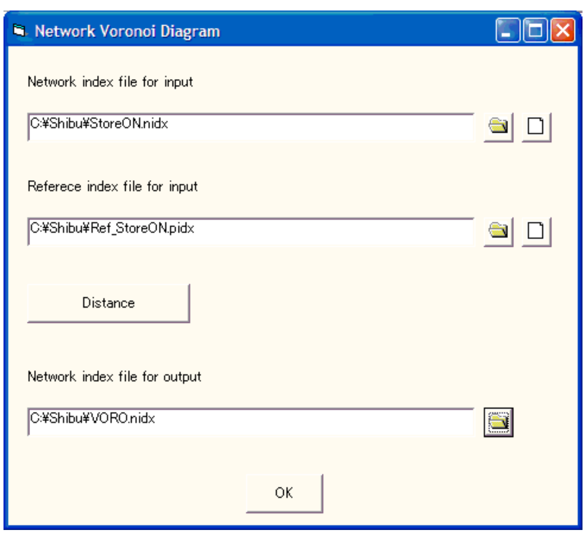
(2) Select the reference index file.

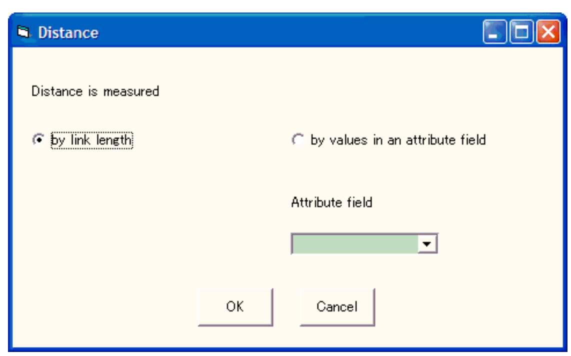
Note: **(1)** and **(2)** has been created as the output of “Insert points to a network” tool.

(3) Distance from a generator point to a location on the network can be measured by the physical link length or any other weight (ex. time distance, any kind of cost). Click “Distance” and choose one. If you checked “by values in an attribute field”, select an attribute field in the drop down menu.

(4) Specify the filename of the output network index file.

(1)
(2)
(3)
(4)





Outputs

(1) Polyline point shapefile (filename: *Network Index file* _v).

NodeID	Point ID.
head	Pointer to the record number of “the adjacent node table”.

ghead	Pointer to the record number of “the nearest path table”.
gghead	Pointer to the record number of “the generator point table”. -1: Pointer to nowhere.
x	X coordinate.
y	Y coordinate.
C_Point	1: collision point, 0: other point.
BoundPoint	1: boundary point, 0: other point.

Note: Collision points and boundary points are added in this file. A collision point is a point which has multiple different routes of the same values of the shortest path distances toward one generator point. Boundary point is a point which has the same values of the shortest path distances to multiple generator points.

Attributes of VORO_v

FID	Shape	NodeID	X	Y	head	ghead	gghead	C_Point	BoundPoint
0	Point	1	-12366.674805	-37769.699219	0	0	-1	0	0
1	Point	2	-12331.625	-37739.175781	3	1	-1	0	0
2	Point	3	-12511.349609	-37730	4	2	-1	0	0
3	Point	4	-12500	-37733.449219	5	3	-1	0	0
4	Point	5	-11340.424805	-37761.925781	7	4	-1	0	0
5	Point	6	-11330.200195	-37770.699219	9	5	-1	0	0
6	Point	7	-12283.25	-37771.648438	12	6	-1	0	0
7	Point	8	-12266	-37753.125	16	7	-1	0	0
8	Point	9	-12323.125	-37732.175781	18	8	-1	0	0
9	Point	10	-11580.799805	-37780.75	19	9	-1	0	0

(2) Network polyline shapefile (filename: *network index file*).

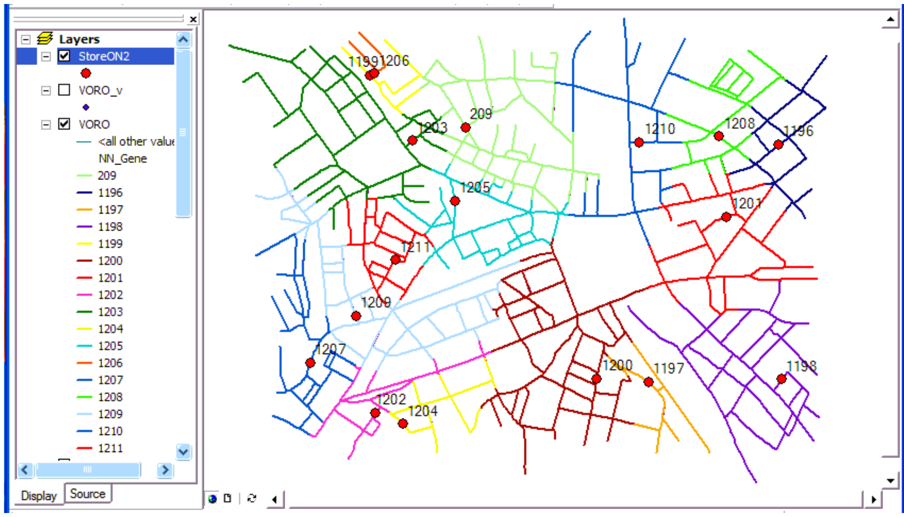
NN_Gene	ID numbers of the nearest generator point.
direc	Direction of the link.
rate	The ratio of the output polyline part length to the original polyline part length.
PartID	ID number of the input polyline.

Attributes of VORO

FID	Shape	rate	PartID	direc	NN_Gene
0	Polyline	1	0	1	1203
1	Polyline	1	1	1	1203
2	Polyline	1	2	1	1203
3	Polyline	1	3	1	1203
4	Polyline	0.540345	4	1	1208
5	Polyline	0.883027	5	1	1208
6	Polyline	0.206097	6	1	1208
7	Polyline	0.855073	7	1	1208
8	Polyline	0.095302	8	1	1203

Network polyline shapefile

You can see the . Double click on the polyline shapefile in the table of contents, and “Layer Property Box” will appear. Click “Symbol” in the menu bar and double click “Category” in the “Show” box to the left. Select “NN_Gene” in the “Field” dropdown menu. Click “Add All” and then, click “Apply”.

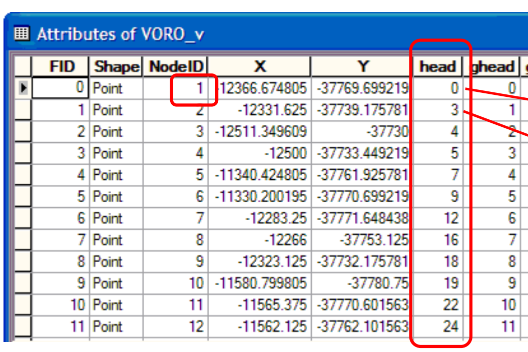


Colored polylines in terms of the nearest generator

(3) Adjacent node table (filename: <u>*network index file*</u> .atbl.dbf).

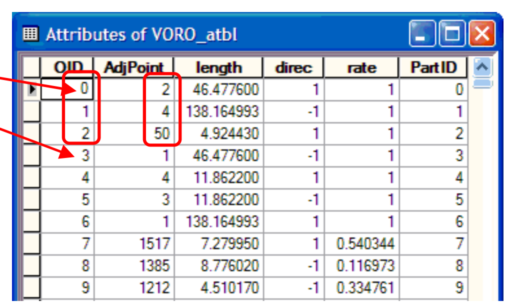
AdjPoint	Adjacent polyline point ID.
Length	Link length.
direc	Direction of the link.
rate	The ratio of the output polyline part length to the original polyline part length.
PartID	ID number of the input polyline.

The figure below illustrates that the polyline point 1 is pointing the record number 0 of the adjacent node table, which indicates three polyline points 2, 4 and 50 are adjacent to the polyline point 1.



Attributes of VORO_v

FID	Shape	NodeID	X	Y	head	ghead
0	Point	1	12366.674805	-37769.699219	0	0
1	Point	2	-12331.625	-37739.175781	3	1
2	Point	3	-12511.349609	-37730	4	2
3	Point	4	-12500	-37733.449219	5	3
4	Point	5	-11340.424805	-37761.925781	7	4
5	Point	6	-11330.200195	-37770.699219	9	5
6	Point	7	-12283.25	-37771.648438	12	6
7	Point	8	-12266	-37753.125	16	7
8	Point	9	-12323.125	-37732.175781	18	8
9	Point	10	-11580.799805	-37780.75	19	9
10	Point	11	-11565.375	-37770.601563	22	10
11	Point	12	-11562.125	-37762.101563	24	11



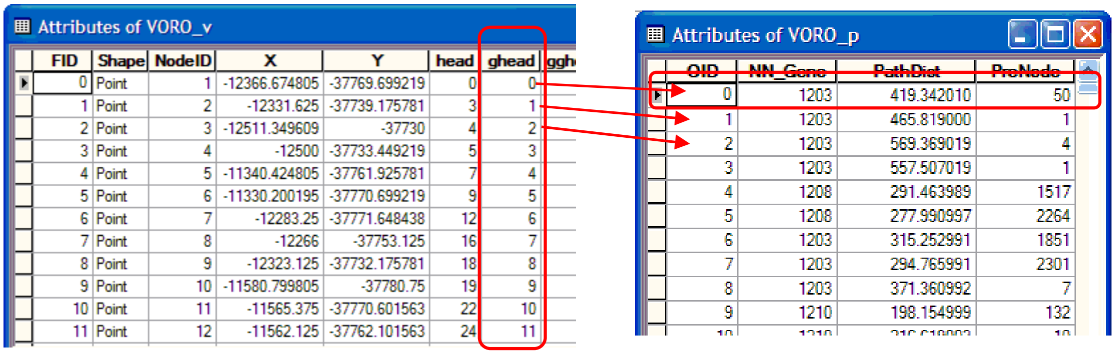
Attributes of VORO_atbl

OID	AdjPoint	length	direc	rate	PartID
0	2	46.477600	1	1	0
1	4	138.164993	-1	1	1
2	50	4.924430	1	1	2
3	1	46.477600	-1	1	3
4	4	11.862200	1	1	4
5	3	11.862200	-1	1	5
6	1	138.164993	1	1	6
7	1517	7.279950	1	0.540344	7
8	1385	8.776020	-1	0.116973	8
9	1212	4.510170	-1	0.334761	9

Attribute table of polyline point shapefile "VORO_v" Adjacent node table "VORO.atbl.dbf"

(4) Nearest path table (filename: <u>*network index file*</u> _p.dbf).

NN_Gene	ID number of the nearest generator point.
PathDist	Shortest path distance to the nearest generator point.
PreNode	Predecessor polyline point ID on the way to the nearest generator point.



Attributes of VORO_v

FID	Shape	NodeID	X	Y	head	ghead
0	Point	1	-12366.674805	-37769.699219	0	0
1	Point	2	-12331.625	-37739.175781	3	1
2	Point	3	-12511.349609	-37730	4	2
3	Point	4	-12500	-37733.449219	5	3
4	Point	5	-11340.424805	-37761.925781	7	4
5	Point	6	-11330.200195	-37770.699219	9	5
6	Point	7	-12283.25	-37771.648438	12	6
7	Point	8	-12266	-37753.125	16	7
8	Point	9	-12323.125	-37732.175781	18	8
9	Point	10	-11580.799805	-37780.75	19	9
10	Point	11	-11565.375	-37770.601563	22	10
11	Point	12	-11562.125	-37762.101563	24	11

Attributes of VORO_p

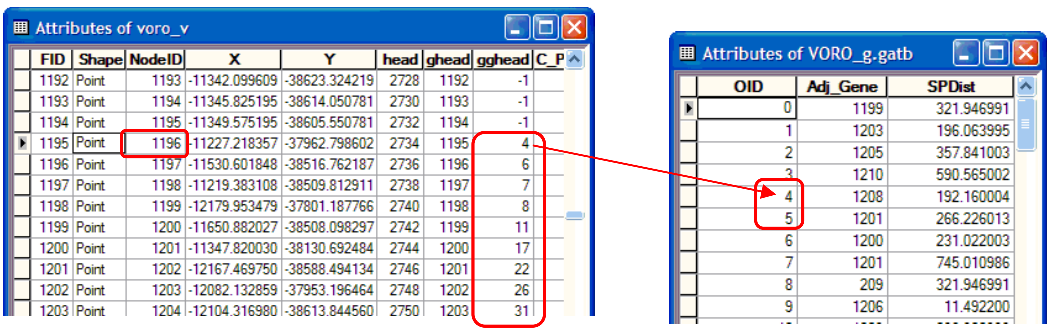
OID	NN_Gene	PathDist	PreNode
0	1203	419.342010	50
1	1203	465.819000	1
2	1203	569.369019	4
3	1203	557.507019	1
4	1208	291.463989	1517
5	1208	277.990997	2264
6	1203	315.252991	1851
7	1203	294.765991	2301
8	1203	371.360992	7
9	1210	198.154999	132

Attribute table of polyline point shapefile "VORO_v" and the nearest path table "VORO_p.dbf"

(5) Generator point table (filename: <u>*Generator point shapefile*</u>_g.gatb.dbf).

A table showing the adjacency among generators.

Adj_Gene	ID number of the adjacent generator.
SPDist	Shortest path distance between two generators.



Attributes of voro_v

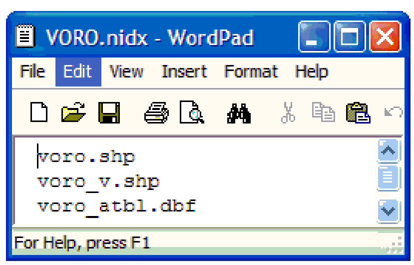
FID	Shape	NodeID	X	Y	head	ghead	gghead	C_P
1192	Point	1193	-11342.099609	-38623.324219	2728	1192	-1	
1193	Point	1194	-11345.825195	-38614.050781	2730	1193	-1	
1194	Point	1195	-11349.575195	-38605.550781	2732	1194	-1	
1195	Point	1196	-11227.218357	-37962.798602	2734	1195	4	
1196	Point	1197	-11530.601848	-38516.762187	2736	1196	6	
1197	Point	1198	-11219.383108	-38509.812911	2738	1197	7	
1198	Point	1199	-12179.953479	-37801.187766	2740	1198	8	
1199	Point	1200	-11650.882027	-38508.098297	2742	1199	11	
1200	Point	1201	-11347.820030	-38130.692484	2744	1200	17	
1201	Point	1202	-12167.469750	-38588.494134	2746	1201	22	
1202	Point	1203	-12082.132859	-37953.196464	2748	1202	26	
1203	Point	1204	-12104.316980	-38613.844560	2750	1203	31	

Attributes of VORO_g.gatb

OID	Adj_Gene	SPDist
0	1199	321.946991
1	1203	196.063995
2	1205	357.841003
3	1210	590.565002
4	1208	192.160004
5	1201	266.226013
6	1200	231.022003
7	1201	745.010986
8	209	321.946991
9	1206	11.492200

Node 1196 is incident to two generators 1208 and 1201, as is seen in the figure above.

(6) Network index file

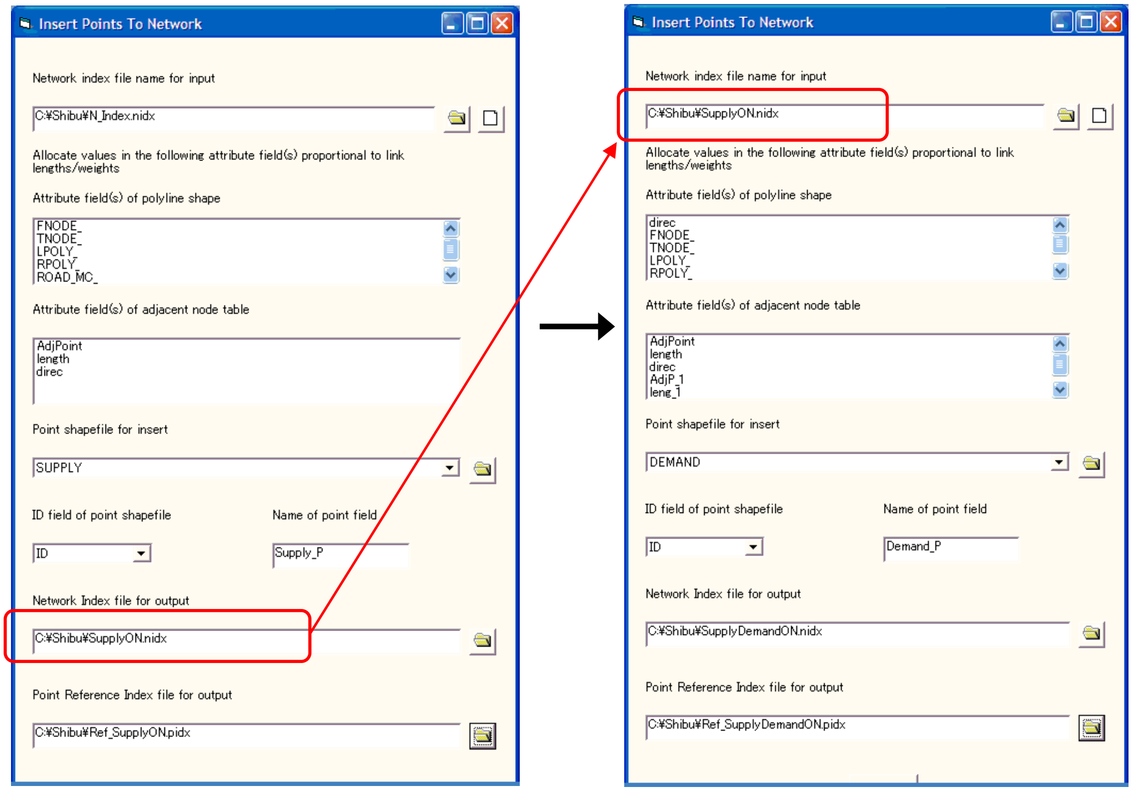


4.2.2 Huff model

This tool estimates the probability that a consumer at any point on the network chooses the supply points and calculates the total amount of demand that the supply points attract.

Inputs

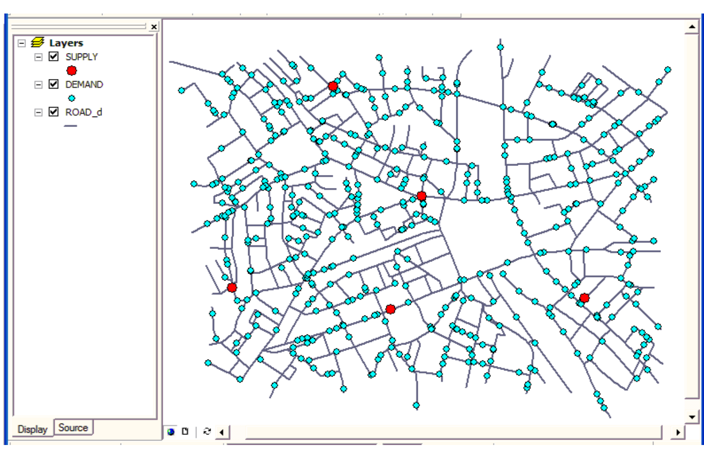
Note: As the supply points and the demand points should have been assigned to the same network before applying this tool, apply "Insert points to a network" tool twice on the network as shown below.



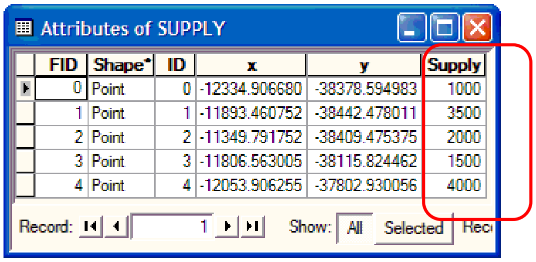
Step1: Assign the supply points to a network.

Step2: Assign the demand points to the network that has been derived as the output of step1.

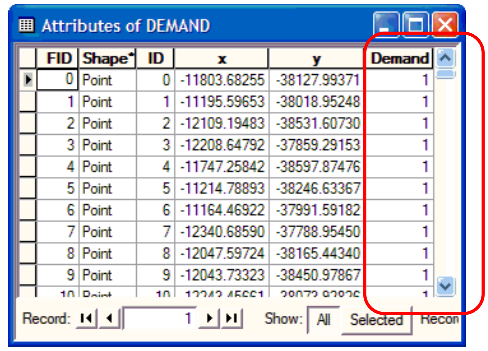
Whereas supply points should have an attribute field of attractiveness such as a sales volume and area of each store, demand points should have an attribute field of a demand volume such as the number of family members.



Polyline shapefile "Road_d", supply point shapefile "SUPPLY" and demand point shapefile "DEMAND"



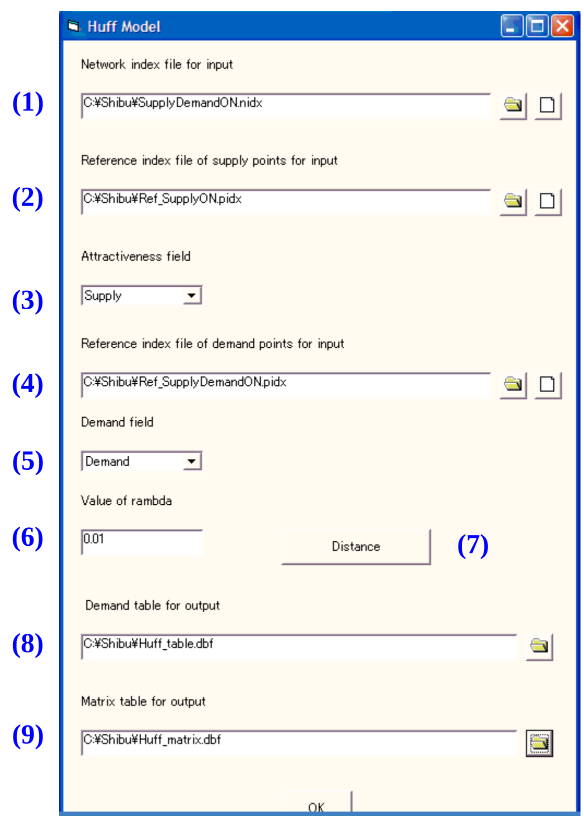
FID	Shape*	ID	x	y	Supply
0	Point	0	-12334.906680	-38378.594983	1000
1	Point	1	-11893.460752	-38442.478011	3500
2	Point	2	-11349.791752	-38409.475375	2000
3	Point	3	-11806.563005	-38115.824462	1500
4	Point	4	-12053.906255	-37802.930056	4000

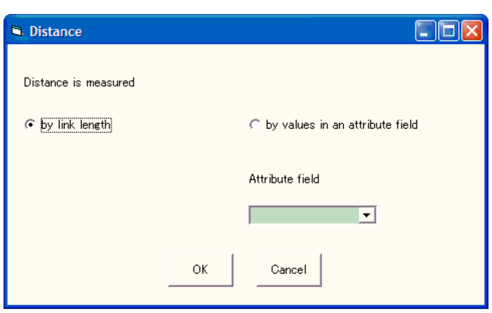


FID	Shape*	ID	x	y	Demand
0	Point	0	-11803.68255	-38127.99371	1
1	Point	1	-11195.59653	-38018.95248	1
2	Point	2	-12109.19483	-38531.60730	1
3	Point	3	-12208.64792	-37859.29153	1
4	Point	4	-11747.25842	-38597.87476	1
5	Point	5	-11214.78893	-38246.63367	1
6	Point	6	-11164.46922	-37991.59182	1
7	Point	7	-12340.68590	-37788.95450	1
8	Point	8	-12047.59724	-38165.44340	1
9	Point	9	-12043.73323	-38450.97867	1

Attribute tables of the supply point and the demand point shapefiles.

1. Select "Huff Model" in **Analysis** menu.
2. Fill in the dialogue box.
    (1) Specify the network index file.
    (2) Select the reference index file of the supply point shapefile.
    (3) Select the attractiveness field in the attribute fields of the supply point shapefile.
    (4) Select the reference index file of the demand point shapefile.
    (5) Select the demand field in the attribute fields of the demand point shapefile.
    (6) Input lambda value. (Refer to the probability function below for details).
    (7) Distance from a point to another point can be measured by the physical link lengths or any other weight. Click "Distance" and choose one. If you checked "by values in an attribute field", select an attribute field in the drop down menu.
    (8) Specify the filename of "the demand table".
    (9) Specify the filename of "the matrix table".





Note: Probability P_{ij} that a consumer at a demand point *i* chooses a supply point *j* is represented as

$$Pij = \frac{Aj\,\exp(-\lambda\ dij)}{\sum_j Aj\,\exp(-\lambda\ dij)}$$

where,

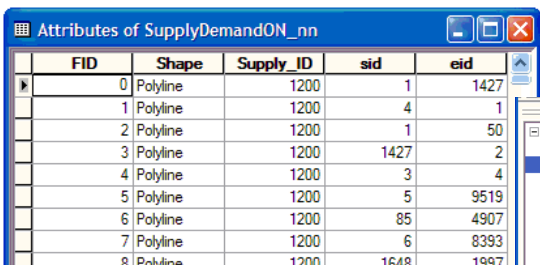
A_j : Attractiveness value (amount of supply) of a supply point *j*,

d_{ij} : Distance from a consumer *i* to a supply point *j*.

Outputs

(1) Network polyline shapefile (filename: <u>*network polyline shapefile*</u> _nn).

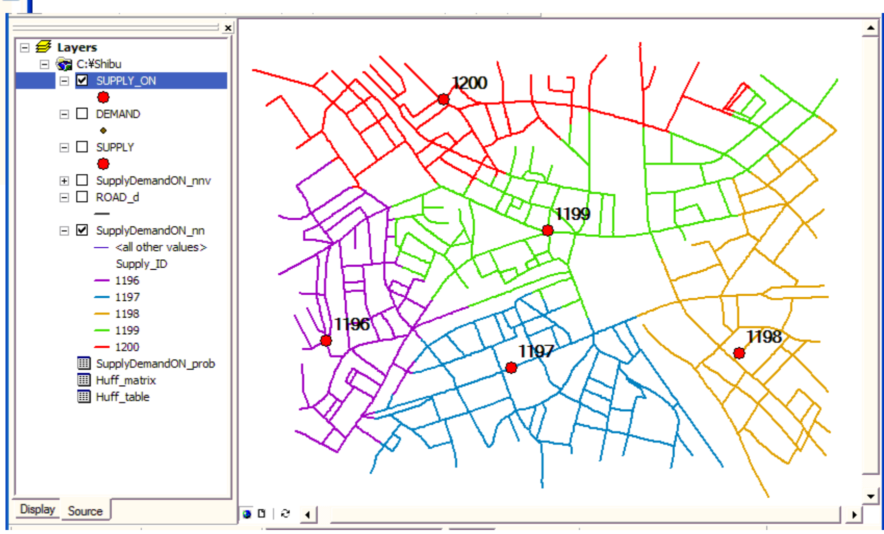
Supply_ID	Supply point ID that the probability of being selected by a consumer located on the link becomes the largest.
sid	Starting node on the link.
eid	Ending node on the link.



Attributes of SupplyDemandON_nn

FID	Shape	Supply_ID	sid	eid
0	Polyline	1200	1	1427
1	Polyline	1200	4	1
2	Polyline	1200	1	50
3	Polyline	1200	1427	2
4	Polyline	1200	3	4
5	Polyline	1200	5	9519
6	Polyline	1200	85	4907
7	Polyline	1200	6	8393
8	Polyline	1200	1648	1997

Polyline shapefile “SupplyDemandON_nn”



Links colored in terms of “Supply ID”

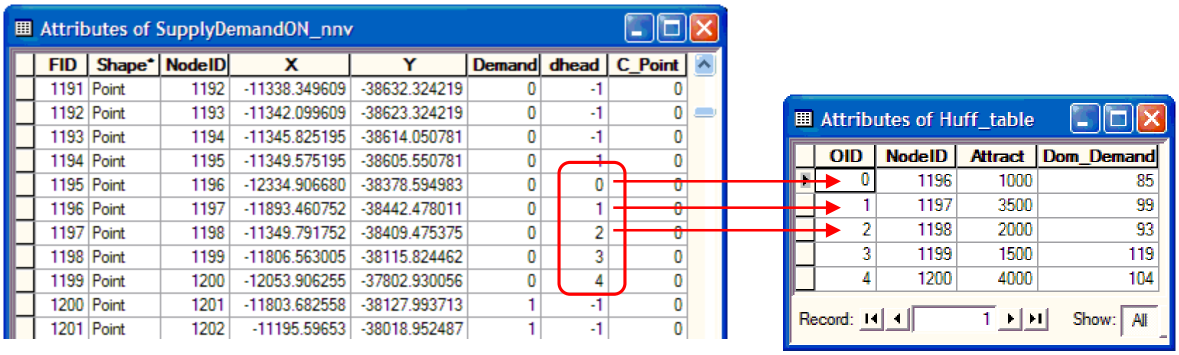
(2) Polyline point shapefile (filename: <u>*network polyline shapefile*</u> _nnv).

Point shapefile consisting of polyline points, collision points, demand points and supply points.

NodeID	Point ID.
X	X coordinate.
Y	Y coordinate.
Demand	0<: Demand point, 0: other point.
dhead	-1<: Pointer to “the demand table”. -1: Pointer to nowhere.
C_Point	1: Collision point, 0: other point.

(3) Demand table (filename: *demand table* .dbf).

NodeID	Supply point ID.
Attract	The amount of attractiveness.
Dom_Demand	Total amount of demand that the supply point has attracted.



Attributes of SupplyDemandON_nnv

FID	Shape*	NodeID	X	Y	Demand	dhead	C_Point
1191	Point	1192	-11338.349609	-38632.324219	0	-1	0
1192	Point	1193	-11342.099609	-38623.324219	0	-1	0
1193	Point	1194	-11345.825195	-38614.050781	0	-1	0
1194	Point	1195	-11349.575195	-38605.550781	0	-1	0
1195	Point	1196	-12334.906680	-38378.594983	0	0	0
1196	Point	1197	-11893.460752	-38442.478011	0	1	0
1197	Point	1198	-11349.791752	-38409.475375	0	2	0
1198	Point	1199	-11806.563005	-38115.824462	0	3	0
1199	Point	1200	-12053.906255	-37802.930056	0	4	0
1200	Point	1201	-11803.682558	-38127.993713	1	-1	0
1201	Point	1202	-11195.59653	-38018.952487	1	-1	0

Attributes of Huff_table

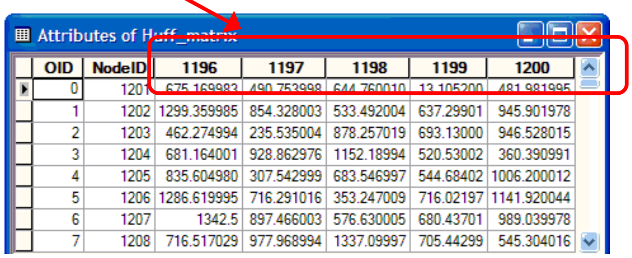
OID	NodeID	Attract	Dom_Demand
0	1196	1000	85
1	1197	3500	99
2	1198	2000	93
3	1199	1500	119
4	1200	4000	104

Polyline point shapefile "SupplyDemandON_nnv"

The attribute of the demand table

(4) Marix table (filename: *matrix table* .dbf).

	NodeID	Demand point ID.
Multiple fields	Supply point ID	Shortest path distance to the supply point.



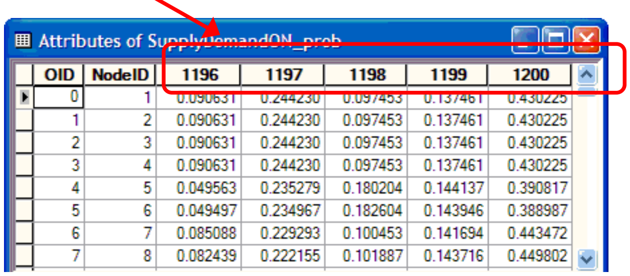
Attributes of Huff_matrix

OID	NodeID	1196	1197	1198	1199	1200
0	1201	675.169983	490.753998	644.760010	13.105200	481.981995
1	1202	1299.359985	854.328003	533.492004	637.29901	945.901978
2	1203	462.274994	235.535004	878.257019	693.13000	946.528015
3	1204	681.164001	928.862976	1152.18994	520.53002	360.390991
4	1205	835.604980	307.542999	683.546997	544.68402	1006.200012
5	1206	1286.619995	716.291016	353.247009	716.02197	1141.920044
6	1207	1342.5	897.466003	576.630005	680.43701	989.039978
7	1208	716.517029	977.968994	1337.09997	705.44299	545.304016

Matrix table of demand points "Huff_matrix.dbf"

(5) Choice probability table (filename: *network polyline shapefile* _prob.dbf).

	NodeID	Polyline point ID.
Multiple fields	Supply point ID	Probability that a customer located at the point selects the supply point.

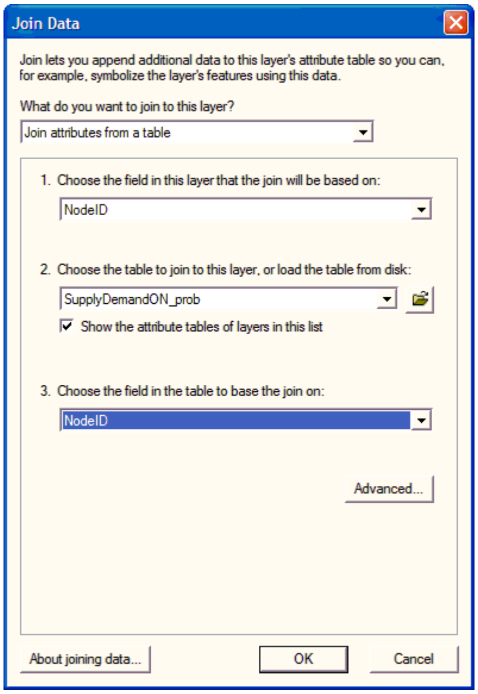


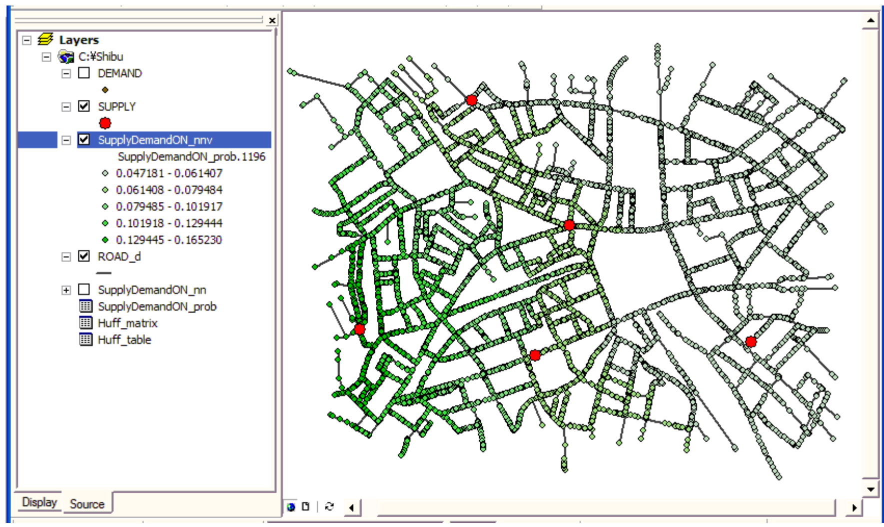
Attributes of SupplyDemandON_prob

OID	NodeID	1196	1197	1198	1199	1200
0	1	0.090631	0.244230	0.097453	0.137461	0.430225
1	2	0.090631	0.244230	0.097453	0.137461	0.430225
2	3	0.090631	0.244230	0.097453	0.137461	0.430225
3	4	0.090631	0.244230	0.097453	0.137461	0.430225
4	5	0.049563	0.235279	0.180204	0.144137	0.390817
5	6	0.049497	0.234967	0.182604	0.143946	0.388987
6	7	0.085088	0.229293	0.100453	0.141694	0.443472
7	8	0.082439	0.222155	0.101887	0.143716	0.449802

Choice probability table of the polylinepoints "SupplyDemandON_prob"

You can see the probability distribution of the customer on each point selecting the particular supply point by joining the polyline point shapefile and the choice probability table.





Probability of the customer at each point selecting the supply point 1196

4.2.3 Nearest neighbor distance method

This tool investigates the locational tendency of one type of points and tests the randomness of that distribution on a network by the nearest neighbor distance method. The tool derives upper and lower 5% confidence interval by the Monte Carlo simulations.

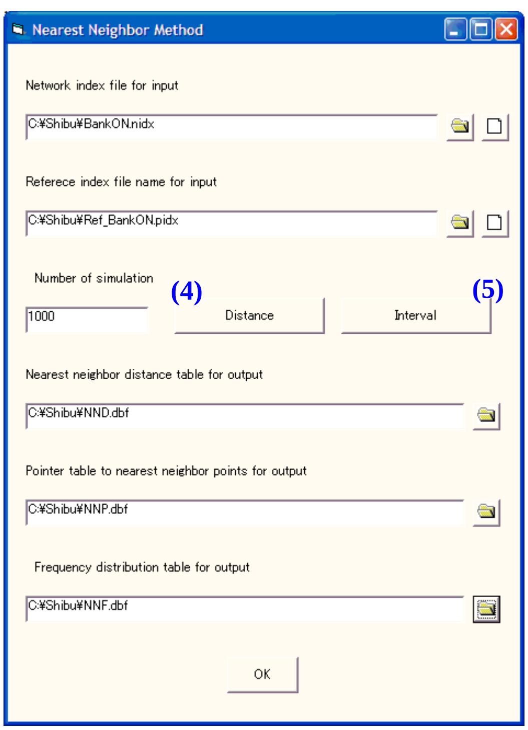
Network polyline shapefile “ROAD_d” and point shapefile “BANK”

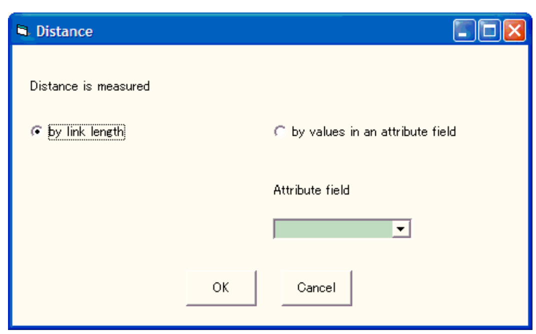
Inputs

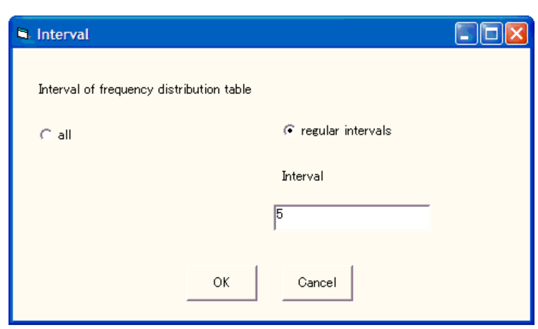
1. Select “Nearest Neighbor Method” in **Analysis** menu.

2. Fill in the dialogue box.
   - **(1)** Specify the network index file.
   - **(2)** Select the reference index file.
   - **(3)** Put the number of the Monte Carlo simulations.
   - **(4)** Distance from a point to the nearest point can be measured by the physical link lengths or any other weight. Click “Distance” and choose one. If you checked “by values in an attribute field”, select an attribute field in the drop down menu.
   - **(5)** Specify the interval distance to make the output frequency distribution table. Check one of two check boxes. If you checked “regular intervals”, specify the interval distance.
   - **(6)** Specify the filename of “the nearest neighbor distance table”.
   - **(7)** Specify the filename of “the pointer table to the nearest neighbor point”.
   - **(8)** Specify the filename of “the frequency distribution table”.

(1)
(2)
(3)
(6)
(7)
(8)







Outputs

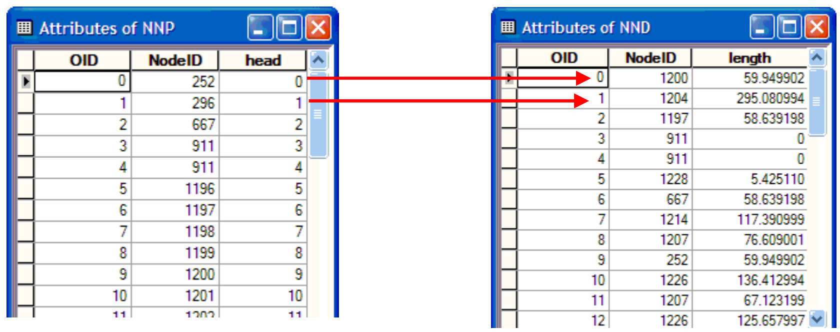
Tree DBF files will be created.

(1) Pointer table to the nearest neighbor point.

NodeID	Point ID.
head	Pointer to the record number in “the nearest neighbor distance table”.

(2) Nearest neighbor distance table.

NodeID	Nearest point ID.
length	Shortest path distance between two points.



Attributes of NNP

OID	NodeID	head
0	252	0
1	296	1
2	667	2
3	911	3
4	911	4
5	1196	5
6	1197	6
7	1198	7
8	1199	8
9	1200	9
10	1201	10

Attributes of NND

OID	NodeID	length
0	1200	59.949902
1	1204	295.080994
2	1197	58.639198
3	911	0
4	911	0
5	1228	5.425110
6	667	58.639198
7	1214	117.390999
8	1207	76.609001
9	252	59.949902
10	1226	136.412994
11	1207	67.123199
12	1226	125.657997

Pointer table to the nearest neighbor point “NNP.dbf” Nearest neighbor distance table “NND.dbf”

(3) Frequency distribution table. (not a complete sentence)

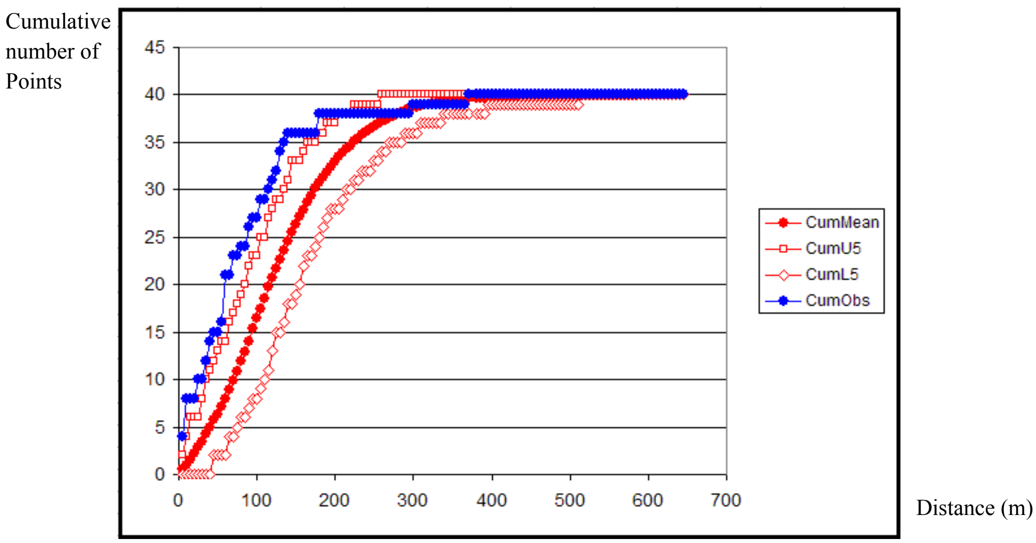
Values which belong to the fields grouped in the expected distribution are derived by the Monte Carlo simulations.

	FromDist	Starting distance of the (“OID” +1)th interval.
	ToDist	Ending distance of the (“OID” +1)th interval.
Expected distribution	Max	Maximum number of points located to each other within the (“OID” +1)th interval.
	Min	Minimum number of points located to each other within the (“OID” +1)th interval.
	Mean	Mean number of points located to each other within the (“OID” +1)th interval.
	Upper5%	The number of points at the upper 5% level among the simulated number of results.
	Lower5%	The number of points at the lower 5% level among the simulated number of results.
	CumMax	Cumulative number of “Max”.
	CumMin	Cumulative number of “Min”.
	CumMean	Cumulative number of “Mean”.
	CumU5	Cumulative number of “Upper5%”.
	CumL5	Cumulative number of “Lower5%”.
Observed distribution	Observed	Observed number of points located within the interval.
	CumObs	Cumulative observed number of points located nearer than “ToDist”.

OID	FromDist	ToDist	Max	Min	Mean	Upper5%	Lower5%	CumMax	CumMin	CumMean	CumU5	CumL5	Observed	CumObs
0	0	5	4	0	0.525000	2	0	4	0	0.525000	2	0	4	4
1	5	10	4	0	0.432500	2	0	6	0	0.957500	4	0	4	8
2	10	15	4	0	0.615000	2	0	8	0	1.572500	6	0	0	8
3	15	20	6	0	0.582500	4	0	10	0	2.155000	6	0	0	8
4	20	25	4	0	0.682500	4	0	11	0	2.837500	6	0	2	10
5	25	30	8	0	0.630000	4	0	13	0	3.467500	8	0	0	10
6	30	35	5	0	0.740000	4	0	13	0	4.207500	10	0	2	12
7	35	40	8	0	0.792500	4	0	14	0	5	11	0	2	14
8	40	45	6	0	0.75	4	0	15	0	5.75	12	2	1	15

Frequency distribution table “NNF.dbf”

You can make the observed and the expected K function curves by setting “ToDist” as x-axis, and “CumObs”, “CumMean”, “CumU5” and “CumL5” as y-axis.



Observed and expected nearest neighbor curves

If the observed curve comes to the left of the upper 5% nearest neighbor curve in the graph, it shows that the observed points significantly locate near to each other. On the other hand, if the observed curve comes to the right of the lower 5% nearest neighbor curve, it shows that the observed points significantly locate apart to each other.

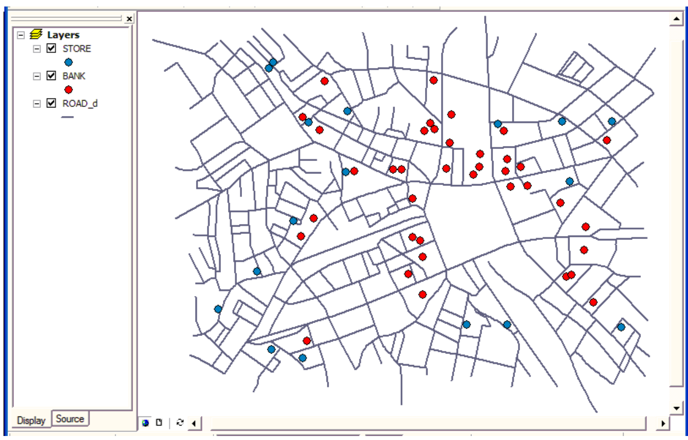
4.2.4 Conditional nearest neighbor distance method

This tool investigates points (of Type A) are independently and randomly distributed with respect to a set of fixed points (of Type B). We call type A points **"non-basic points"**, and type B points **"basic points".**

Note: The basic points and the non-basic points have to be assigned to the network beforehand by applying "Insert points to a network" tool. (See the first part of "Huff model" section for details.)

Inputs

1. Select "Conditional Nearest Neighbor Method" in **Analysis** menu.



Network polyline shapefile "ROAD_d", basic point "STORE" and non-basic point "BANK"

2. Fill in the dialogue box.

(1) Specify the network index file.

(2) Select the reference index file of the basic points.

(3) Select the reference index file of the non-basic points.

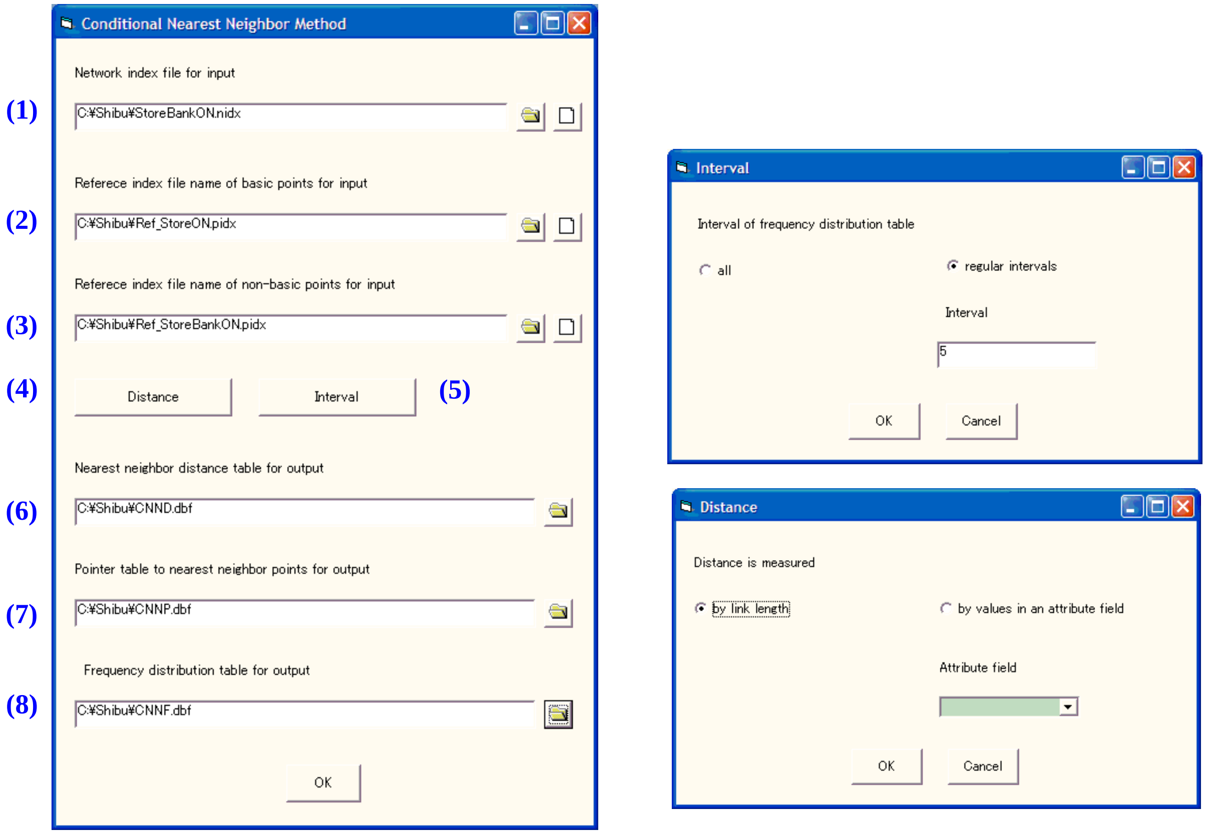
(4) Distance from a basic point to the nearest non-basic point can be measured by the physical link lengths or any other weight. Click "Distance" and choose one. If you checked "by values in an attribute field", select an attribute field in the drop down menu.

(5) Specify the interval distance to make the output frequency distribution table. Check one of two check boxes. If you checked "regular intervals", specify an interval distance.

(6) Specify the filename of "the nearest neighbor distance table".

(7) Specify the filename of "the pointer table to nearest neighbor point".

(8) Specify the filename of "the frequency distribution table".



Outputs

(1) Pointer table to the nearest neighbor point.

NodeID	Point ID of the non-basic points.
head	Pointer to the record number of “the nearest neighbor distance table”.

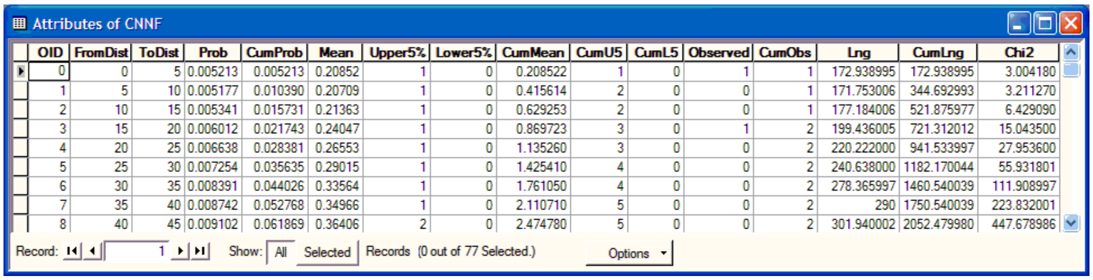
(2) Nearest neighbor distance table.

NodeID	Point ID of the nearest basic point.
length	Shortest path distance between two points.

(3) Frequency distribution table.

FromDist	Starting distance of the (“OID” +1)th interval.
ToDist	Ending distance of the (“OID” +1)th interval.
Prob	The ratio of the link length existing within the interval distance to the total polyline length.
CumProb	Cumulative number of “Prob”.
Mean	“Cumprob” * “the number of non-basic points”.
Upper5%	The number of points at the upper 5% level derived by the binomial distribution.
Lower5%	The number of points at the lower 5% level derived by the binomial distribution.
CumMean	Cumulative number of “Mean”.
CumU5	Cumulative number of “Upper5%”.

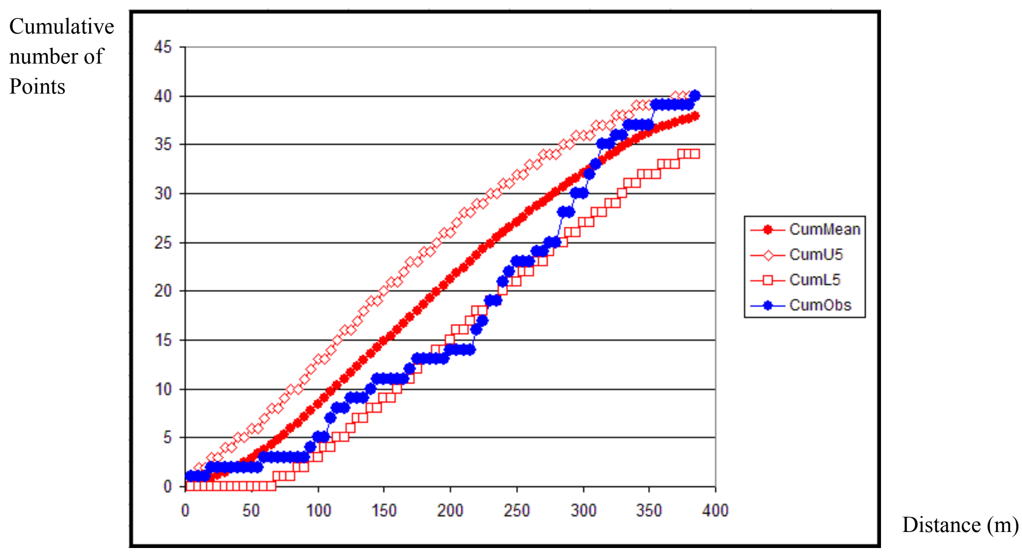
CumL5	Cumulative number of “Lower5%”.
Observed	Observed number of points located within the interval distance.
CumObs	Cumulative observed number of “Observed”.
Lng	The link length existing within the interval distance.
Cum Lng	Cumulative number of “Lng”.
Chi2	Chi squared value of the observed distribution.


Attributes of CNNF

OID	FromDist	ToDist	Prob	CumProb	Mean	Upper5%	Lower5%	CumMean	CumU5	CumL5	Observed	CumObs	Lng	CumLng	Chi2
0	0	5	0.005213	0.005213	0.20852	1	0	0.208522	1	0	1	1	172.938995	172.938995	3.004180
1	5	10	0.005177	0.010390	0.20709	1	0	0.415614	2	0	0	1	171.753006	344.692993	3.211270
2	10	15	0.005341	0.015731	0.21363	1	0	0.629253	2	0	0	1	177.184006	521.875977	6.429090
3	15	20	0.006012	0.021743	0.24047	1	0	0.869723	3	0	1	2	199.436005	721.312012	15.043500
4	20	25	0.006638	0.028381	0.26553	1	0	1.135260	3	0	0	2	220.222000	941.533997	27.953600
5	25	30	0.007254	0.035635	0.29015	1	0	1.425410	4	0	0	2	240.638000	1182.170044	55.931801
6	30	35	0.008391	0.044026	0.33564	1	0	1.761050	4	0	0	2	278.365997	1460.540039	111.908997
7	35	40	0.008742	0.052768	0.34966	1	0	2.110710	5	0	0	2	290	1750.540039	223.832001
8	40	45	0.009102	0.061869	0.36406	2	0	2.474780	5	0	0	2	301.940002	2052.479980	447.678986

Record: 1 Show: All Selected Records (0 out of 77 Selected.) Options

Frequency distribution table “CNNF.dbf”



Observed and expected conditional nearest neighbor curves

If the observed curve is to the left of the expected curve, then it shows the non-basic points tend to locate near to the basic points. On the other hand, if the observed curve is to the right of the expected curve, it shows the basic points and the non-basic points tend to locate apart to each other.

4.2.5 *K* Function method

This tool investigates the locational tendency of one type of points and tests the randomness of that distribution on a network by the *K* function method. The tool derives upper and lower 5% confidence interval by the Monte Carlo simulations.

Inputs

1. Select "*K* Function" in **Analysis** menu.

Network polyline "ROAD_d" and point "BANK"

2. Fill in the dialogue box.

(1) Specify the network index file.

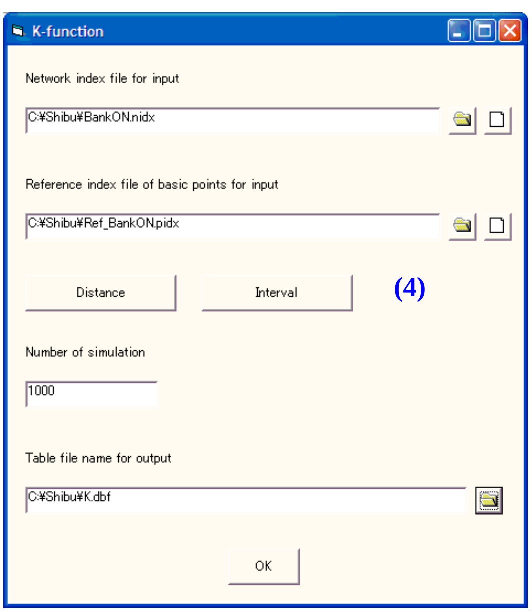
(2) Specify the reference index file.

(3) Distance from a point to the nearest point can be measured by the physical link lengths or any other weight. Click "Distance" and choose one. If you checked "by values in an attribute field", select an attribute field in the drop down menu.

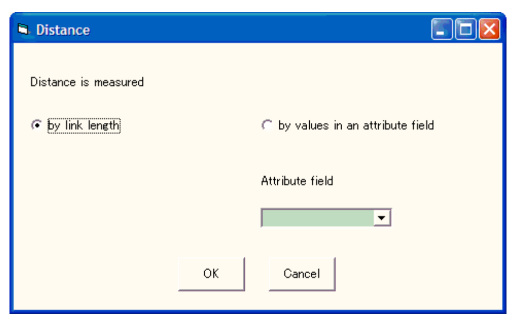
(4) Specify the interval distance to make the output table. Check one of two check boxes. If you checked "regular intervals", specify an interval distance.

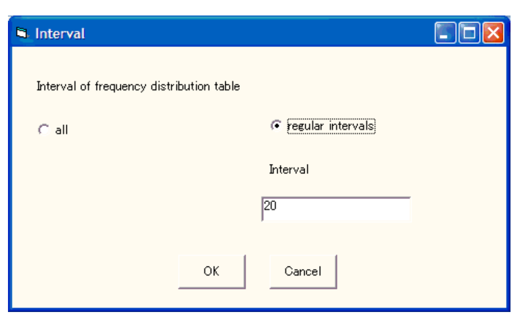
(5) Put the number of simulations.

(6) Specify the name of the output table.



(1) (2) (3) (4) (5) (6)





Outputs

(1) Observed *K* function table (filename: *table file* _o.dbf).

FromDist	Starting distance of the ("OID" +1)th interval.
ToDist	Ending distance of the ("OID" +1)th interval.
Observed	The number of points located within the interval distance.
CumObs	Cumulative numbers of "Observed".

Attributes of K_o

OID	FromDist	ToDist	Observed	CumObs
0	0	20	8	8
1	20	40	6	14
2	40	60	18	32
3	60	80	14	46
4	80	100	14	60
5	100	120	26	86
6	120	140	20	106
7	140	160	30	136
8	160	180	22	158

Observed K function table

(2) Expected *K* function table (filename: table file _e.dbf).

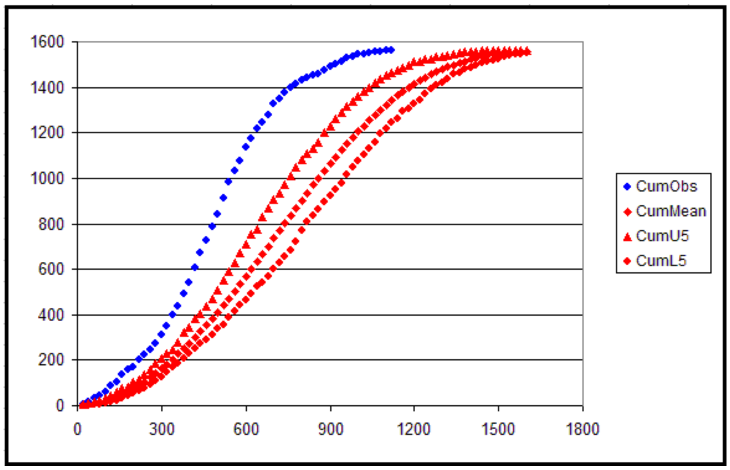
FromDist	Starting distance of the ("OID" +1)th interval.
ToDist	Ending distance of the ("OID" +1)th interval.
Max	Maximum number of points located to each other within the ("OID" +1)th interval.
Min	Minimum number of points located to each other within the ("OID" +1)th interval.
Mean	Mean number of points located to each other within the ("OID" +1)th interval.
Upper5%	The number of points at the upper 5% level among the simulated number of results.
Lowe5%	The number of points at the lower 5% level among the simulated number of results.
CumMax	Cumulative number of "Max".
CumMin	Cumulative number of "Min".
CumMean	Cumulative number of "Mean".
CumU5	Cumulative number of "Upper5%".
CumL5	Cumulative number of "Lower5%".
Links	The number of links existing within the interval distance.

Attributes of K_e

OID	FromDist	ToDist	Max	Min	Mean	Upper5%	Lower5%	CumMax	CumMin	CumMean	CumU5	CumL5	Links
0	0	20	8	0	2.300000	6	0	8	0	2.300000	6	0	80
1	20	40	8	0	2.580000	6	0	14	0	4.880000	10	2	97
2	40	60	18	0	4.5	10	0	30	2	9.380000	18	4	150
3	60	80	20	0	5.160000	10	0	50	2	14.540000	22	6	204
4	80	100	22	0	6.260000	12	2	60	8	20.799999	32	12	249
5	100	120	24	0	7.940000	14	2	76	12	28.740000	46	16	333
6	120	140	26	2	10.080000	18	2	82	16	38.820000	60	24	411
7	140	160	28	2	10.560000	20	4	88	20	49.380001	74	32	471
8	160	180	22	0	11.840000	20	4	104	26	61.220001	84	44	515
9	180	200	30	2	13	24	6	124	44	74.220001	102	54	573
10	200	220	46	6	14.960000	26	6	148	56	89.180000	116	64	676
11	220	240	30	4	16.520000	28	6	176	64	105.699997	138	76	732

Expected *K* function table

Cumulative number of Points



Distance (m)

Observed and expected *K* function curves

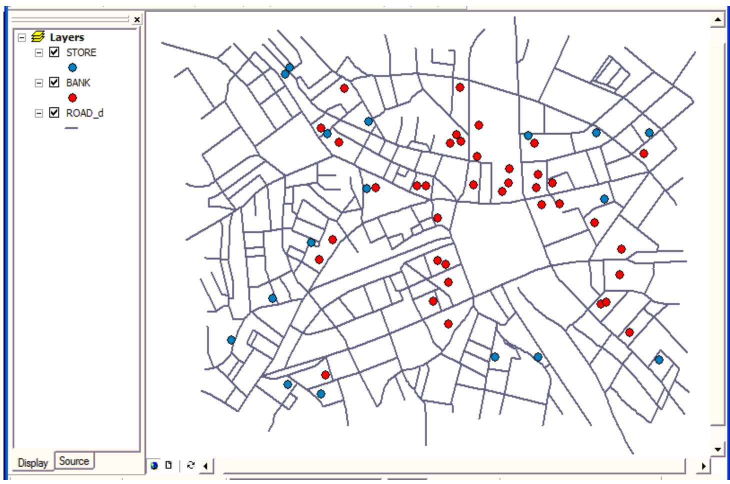
4.2.6 Cross *K* function method

This tool detects the locational tendency whether points (of Type A) are independently and randomly distributed with respect to a set of fixed points (of Type B) by the cross *K* function method. We call type A points “**non-basic points**”, and type B points “**basic points**”.

Inputs

Note: The basic points and the non-basic points have to be assigned to the network beforehand by applying “Insert points to a network” tool.

1. Select “Cross *K* function” in **Analysis** menu.



Network polyline “ROAD_d”, basic point ”STORE”
and non-basic point “BANK”

2. Fill in the dialogue box.

   (1) Specify the network index file.

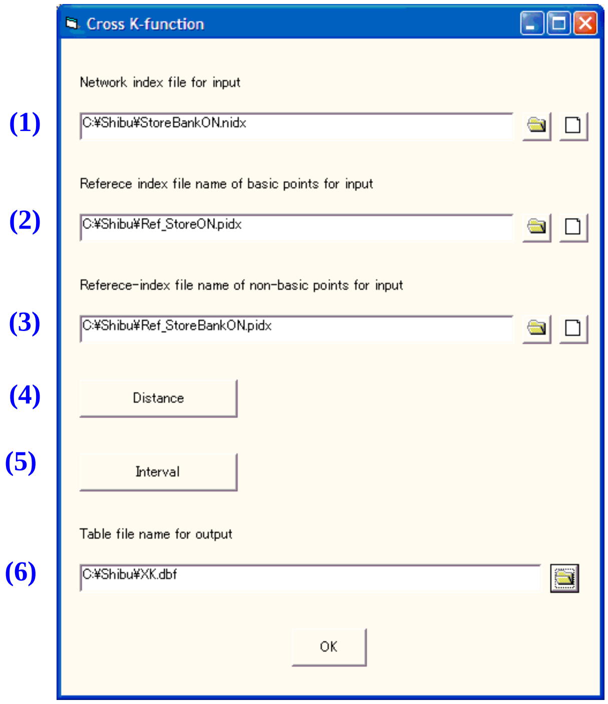
   (2) Specify the reference-index file of the basic point shapefile.

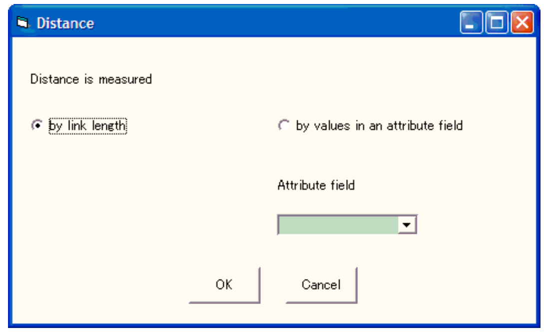
   (3) Specify the reference-index file of the non-basic point shapefile.

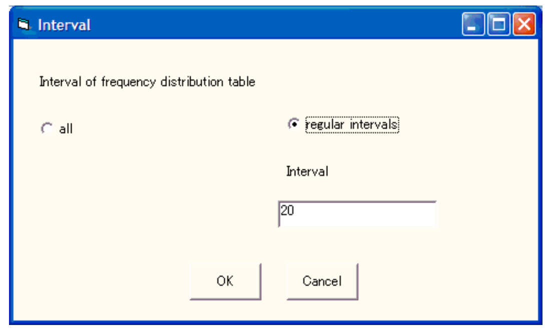
   (4) Distance from the basic points to the non-basic points can be measured by the physical link lengths or any other weight. Click “Distance” and choose one. If you checked “by values in an attribute field”, select an attribute field in the drop down menu.

   (5) Specify the interval distance to make the output table. Check one of two check boxes. If you checked “regular intervals”, specify an interval distance.

   (6) Specify the filename of the output table.



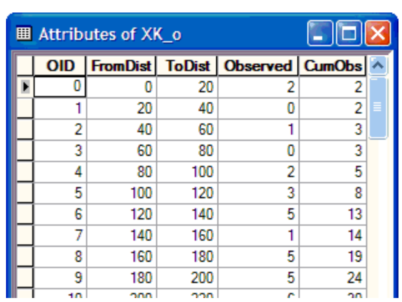




Outputs

(1) Observed *K* function table (filename: *table file* _o.dbf).

FromDist	Starting distance of the (“OID”+1)th interval.
ToDist	Ending distance of the (“OID”+1)th interval.
Observed	The number of the non-basic points located within the interval distance from the basic points.
CumObs	The number of cumulative non-basic points located within the “ToDist” distance from the basic points.


Attributes of XK_o

OID	FromDist	ToDist	Observed	CumObs
0	0	20	2	2
1	20	40	0	2
2	40	60	1	3
3	60	80	0	3
4	80	100	2	5
5	100	120	3	8
6	120	140	5	13
7	140	160	1	14
8	160	180	5	19
9	180	200	5	24

Observed K function table

(2) Expected *K* function table (filename: *table file*_e.dbf)

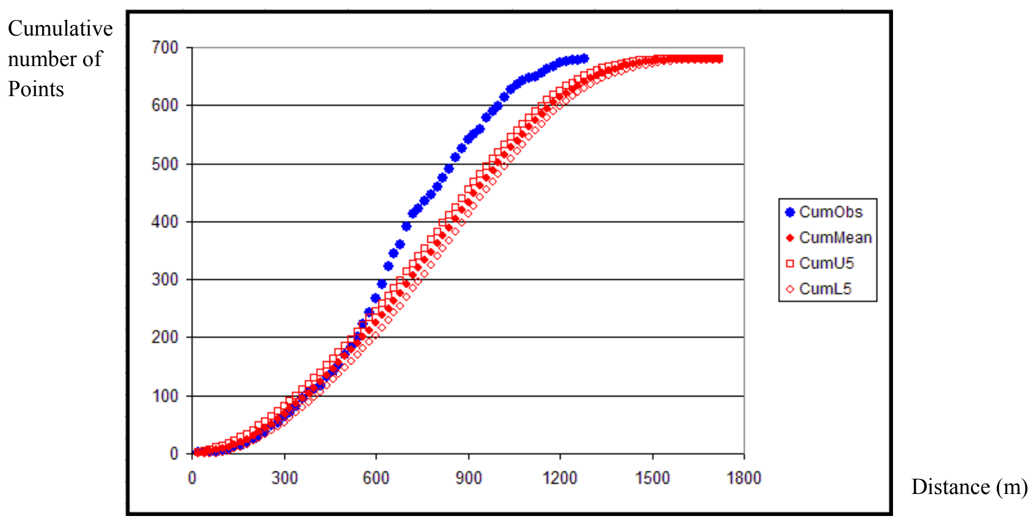
FromDist	Starting distance of the (“OID”+1)th interval.
ToDist	Ending distance of the (“OID”+1)th interval.
Prob	“TotalLinks”/ (the maximum number of total links).
CumProb	Cumulative number of “Prob”.
Mean	Expected mean number of points located within the interval.

Upper5%	The number of points at the upper 5% level derived by the binomial distribution.
Lowe5%	The number of points at the lower 5% level derived by the binomial distribution.
CumMean	Expected number of mean points located nearer than “ToDist” distance.
CumU5	Cumulative number of “Upper5%”.
CumL5	Cumulative number of “Lower5%”.
Links	The number of links existing within the interval distance.
TotalLinks	Cumulative number of (“Links” * the interval distance).

Attributes of XK_e

OID	FromDist	ToDist	Prob	CumProb	Mean	Upper5%	Lower5%	CumMean	CumU5	CumL5	Links	TotalLinks
0	0	20	0	0.001205	0	0	0	0.819422	3	0	34	680
1	20	40	0.001559	0.002764	1.060430	3	0	1.879850	4	0	44	1560
2	40	60	0.002233	0.004997	1.518340	4	0	3.398190	7	0	63	2820
3	60	80	0.003225	0.008223	2.193160	5	0	5.591350	10	1	91	4640
4	80	100	0.003686	0.011909	2.506470	5	0	8.097820	13	3	104	6720
5	100	120	0.004926	0.016835	3.349990	7	0	11.447800	17	5	139	9500
6	120	140	0.005706	0.022541	3.880210	7	0	15.328000	22	8	161	12720
7	140	160	0.006911	0.029452	4.699630	8	0	20.027599	28	12	195	16620
8	160	180	0.007443	0.036895	5.061140	9	1	25.088800	33	16	210	20820
9	180	200	0.008719	0.045614	5.928760	10	1	31.017500	40	21	246	25740
10	200	220	0.009605	0.055219	6.531280	11	2	37.548801	48	27	271	31160
11	220	240	0.010278	0.065497	6.989190	12	2	44.537998	55	33	290	36960
12	240	260	0.010668	0.076165	7.254300	12	2	51.792301	63	40	301	42980

Expected K function table



Observed and expected Cross K function curves

4.2.7 Interpolation

This tool interpolates an unknown attribute value at a location on a network using observed values at some other points in its vicinity, which are called "sample points", by IDW interpolation method. The shortest-path distances from the sample points to the unknown point are used for selecting the fixed number of nearest sample points.

Note: The sample point shapefile should have a field for the observed value. Also, the sample point shapefile and the interpolated point shapefile have to be assigned to the same network applying "Insert points to a network" tool.

Inputs

1. Select "Interpolation" in **Analysis** menu.

Observed points (blue points) with their observed values and the interpolated point (red point)

2. Fill in the dialogue box.

(1) Specify the network index file.

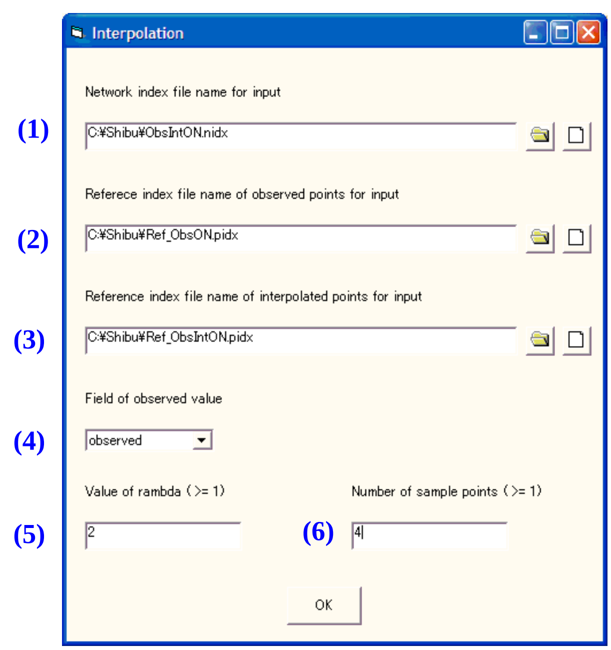
(2) Specify the reference index file of the observed points.

(3) Specify the reference index file of the interpolated points.

(4) Specify the field where the observed values has been stored.

(5) Specify the lambda value, which is the inversed network distance weight.

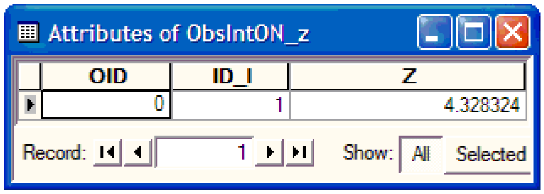
(6) Specify the number of the sample points.



Outputs

Interpolated point table (filename: input network index file _z.dbf). (not sure if you need a period at the end)

ID	ID of the interpolated point. The value corresponds to that in "ID field of point shapefile" specified when "the insert points to a network" tool has been applied.
Z	Interpolated value.



4.2.8 Clumping method

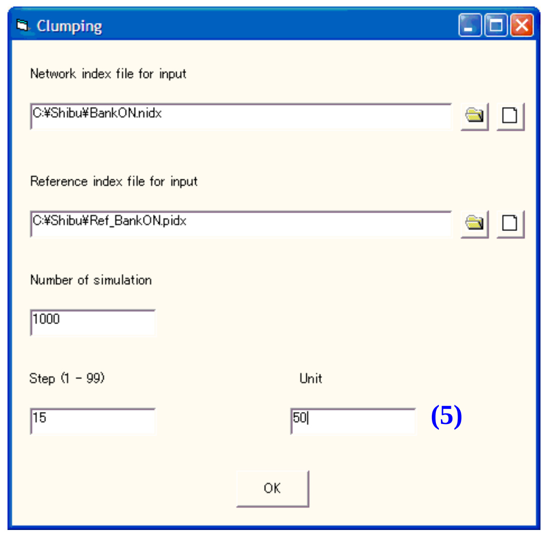
This tool statistically detects hierarchical point clusters among the point distribution.

Inputs

Network polyline shapefile “ROAD_d” and point shapefile “BANK”

1. Select “Clumping” in **Analysis** menu.

2. Fill in the dialogue box.
   - **(1)** Specify the network index file.
   - **(2)** Specify the reference index file.
   - **(3)** Put the number of the Monte Carlo simulations.
   - **(4)** Specify the maximum number of ranks for the cluster detection.
   - **(5)** Specify the interval distance to detect the clusters.

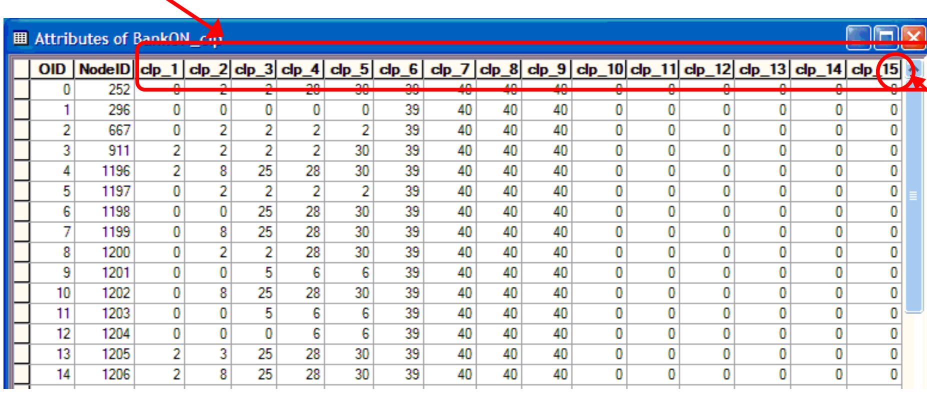


Outputs

Clumping table (filename: *input polyine shapefile* _clp.dbf).

NodeID	Point ID.
clp_#	The number in each cell shows the clump size, which is the number of points consisting one clump.

Multiple fields

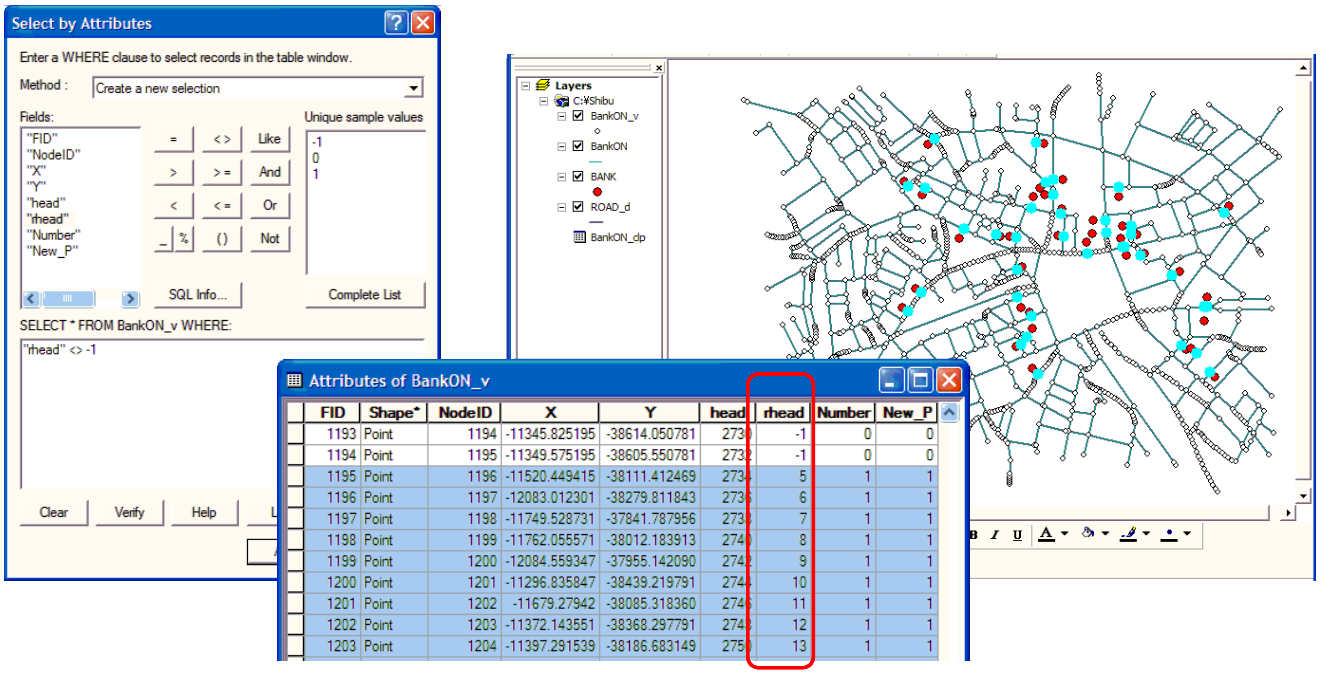

Attributes of BankON_clp

OID	NodeID	clp_1	clp_2	clp_3	clp_4	clp_5	clp_6	clp_7	clp_8	clp_9	clp_10	clp_11	clp_12	clp_13	clp_14	clp_15
0	252	0	2	2	28	30	39	40	40	40	0	0	0	0	0	0
1	296	0	0	0	0	0	39	40	40	40	0	0	0	0	0	0
2	667	0	2	2	2	2	39	40	40	40	0	0	0	0	0	0
3	911	2	2	2	2	30	39	40	40	40	0	0	0	0	0	0
4	1196	2	8	25	28	30	39	40	40	40	0	0	0	0	0	0
5	1197	0	2	2	2	2	39	40	40	40	0	0	0	0	0	0
6	1198	0	0	25	28	30	39	40	40	40	0	0	0	0	0	0
7	1199	0	8	25	28	30	39	40	40	40	0	0	0	0	0	0
8	1200	0	2	2	28	30	39	40	40	40	0	0	0	0	0	0
9	1201	0	0	5	6	6	39	40	40	40	0	0	0	0	0	0
10	1202	0	8	25	28	30	39	40	40	40	0	0	0	0	0	0
11	1203	0	0	5	6	6	39	40	40	40	0	0	0	0	0	0
12	1204	0	0	0	6	6	39	40	40	40	0	0	0	0	0	0
13	1205	2	3	25	28	30	39	40	40	40	0	0	0	0	0	0
14	1206	2	8	25	28	30	39	40	40	40	0	0	0	0	0	0

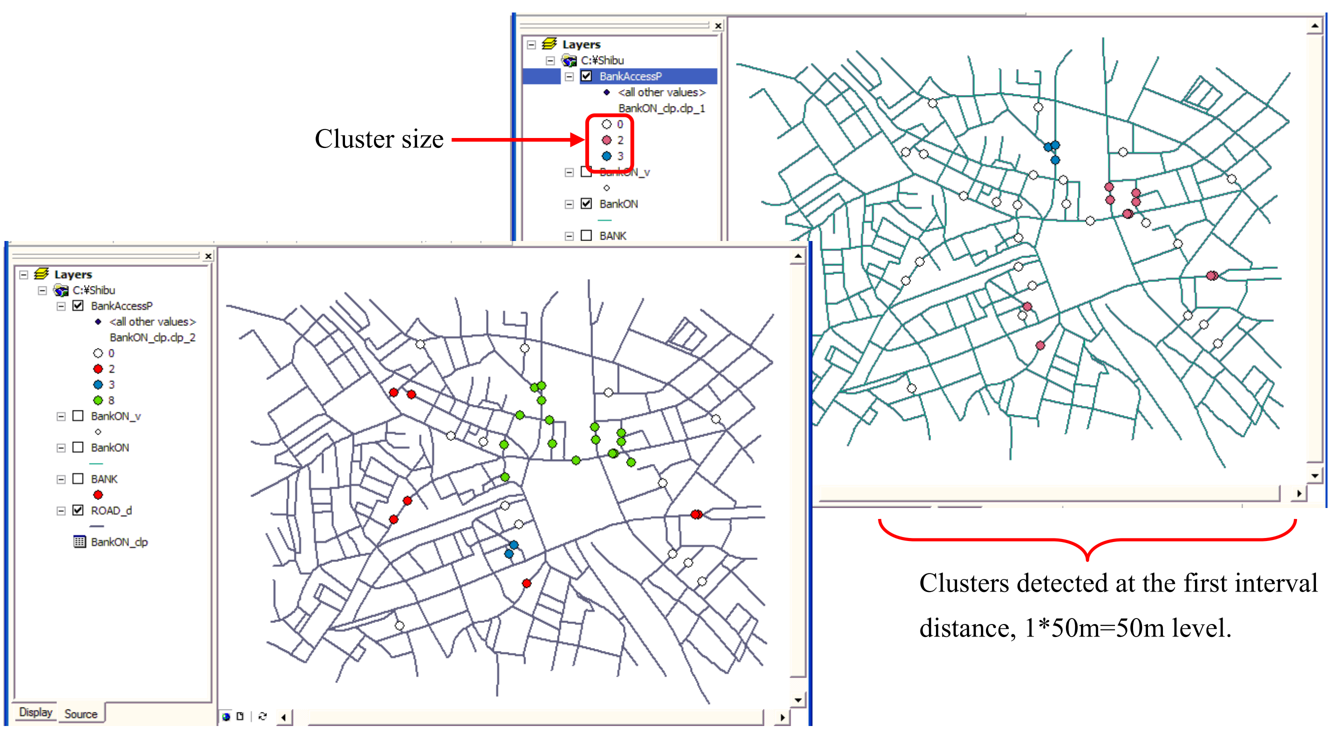
The number you specified at step **(4)**.

Note: The number in # is the distance category for the cluster detection. For example, in the field "Clp_2", you can see the detected clusters at the 2*50m=100m distance level (the second interval distance level). It means three sizes of clusters, 2, 3 and 8, have been detected as shown in the figure below, and points which belong to each cluster are located within 100m to each other.

To see the detected clusters in the project window, join the output table with the access point shapefile.



Extraction the access points from the polyline point shapefile and exporting it to make a new access point shapefile



Clusters detected at the first interval distance, 1*50m=50m level.

Examples of hierarchical clusters

4.2.9 M Function method

This tool analyses the spatial relation between two polylines, the observed polylines and the randomly generated polylines, by applying M function method.

$$\text{M function } (t) = Aa(t) \cap Ab(t) \cap As \quad / As$$

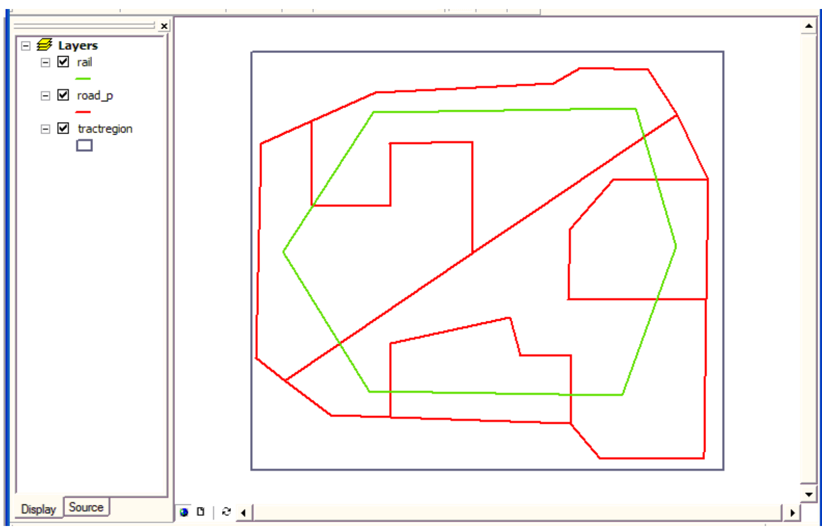
where,

t**:** Distance.
$Aa(t)$**:** Buffer area of the polyline Aa under the buffer distance t.
$Ab(t)$**:** Buffer area of the polyline Ab under the buffer distance t.
As**:** The area of the study region.

Inputs

1. Select "M function" in **Analysis** menu.

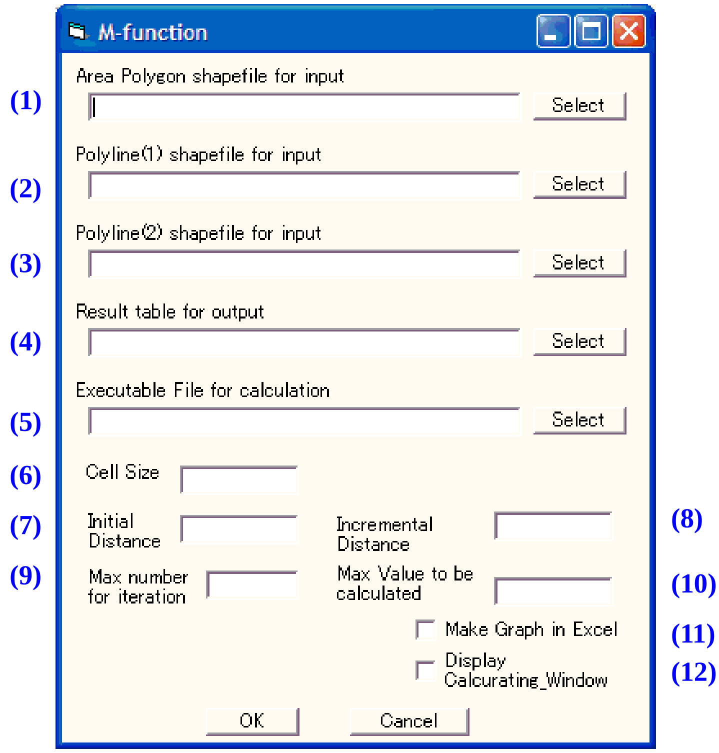
Note: No preprocessing tool has to be applied beforehand for this tool.



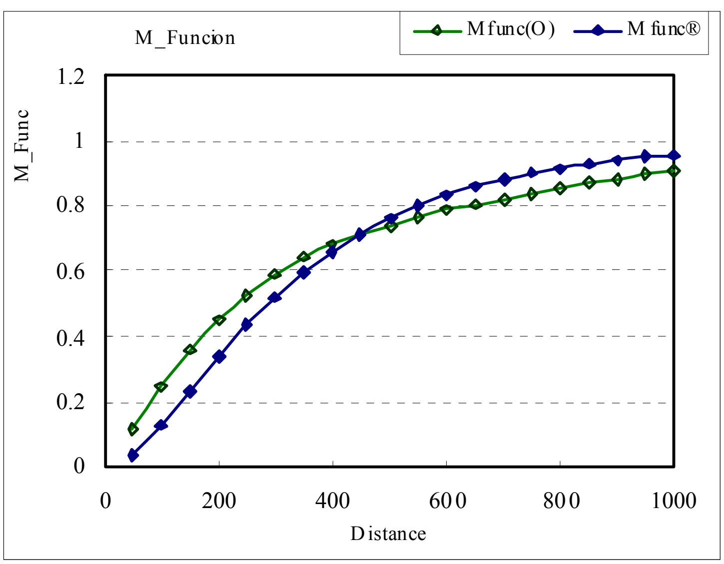
2. Fill in the dialogue box.

(1) Specify the polygon shapefile in which two polyline shapefiles are located.
(2) Specify the first polyline shapefile.
(3) Specify the second polyline shapefile.
(4) Specify the filename of the output table.
(5) Input "calM.exe" here.
(6) Specify the grid size.
(7) Initial distance for making buffer areas around the polylines.
(8) Incremental distance for making buffer areas around the polylines.
(9) Maximum number of iteration of the random line generation.
(10) Maximum value that the calculation is conducted (The value have to be between 0 and 1).
(11) Check if you want to see the result in the graph.

(12) Check if you want to display MS Dos window during the calculation.



Outputs



The observed and the Expected M function curves

Observed value   Expected value

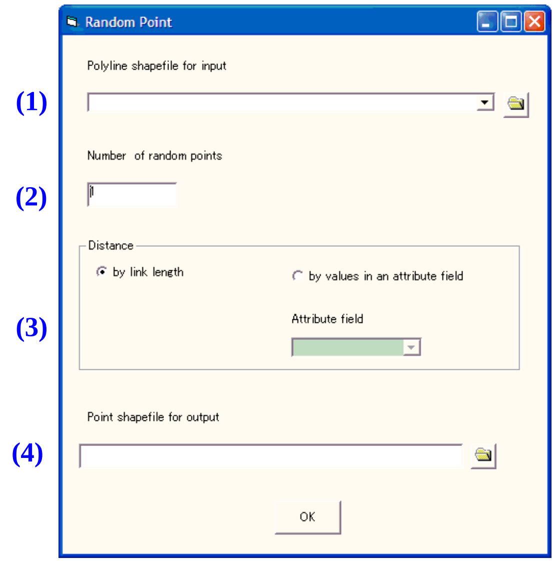
OID	Dist	MFunc(O)	MFunc(R)
0	50	0.114031	0.03391
1	100	0.233481	0.110838
2	150	0.341205	0.205553
3	200	0.436417	0.303725
4	250	0.516185	0.397624
5	300	0.58527	0.483469
6	350	0.639436	0.559778
7	400	0.681085	0.626373
8	450	0.714782	0.683767
9	500	0.743319	0.732808
10	550	0.768423	0.774459
11	600	0.790454	0.80969
12	650	0.809498	0.839407
13	700	0.826688	0.864429
14	750	0.842633	0.885477
15	800	0.857442	0.903175
16	850	0.871335	0.918056
17	900	0.884828	0.930572
18	950	0.898022	0.941107
19	1000	0.910734	0.949979
20	1050	0.921622	0.95746
21	1100	0.930654	0.963774
22	1150	0.937944	0.969109
23	1200	0.944757	0.973623

Note: This tool may not work correctly for a certain type of data. This is under investigation for the moment.

4.3 Other independent tools

4.3.1 Random point

This tool generates random points on the network according to the Poisson point process (i.e. the probability of a point being placed on a unit line segment on a network is the same regardless of the location of the segment).



Inputs

1. Add the network polyline shapefile to the project window.

Note: “Clean” and “Continuous Graph” tools have to be applied on the polyline shapefile beforehand.

2. Select “Random Points” in **ShapeEditor** menu.

3. Fill in the dialogue box.

   (1) Select the polyline shapefile.

   (2) Put the number of random points to be generated.

   (3) Distance on the network can be measured by the physical link length or any other weight. Check one of two check boxes. If you checked in “by values in an attribute field”, select an attribute field in the drop down menu.

   (4) Specify the filename of the output shapefile.

Outputs

Random point shapefile will be created.

RandomID	Random point ID.
X	X coordinate.
Y	Y coordinate.

1000 random points on the network

4.3.2 Polygon centroid

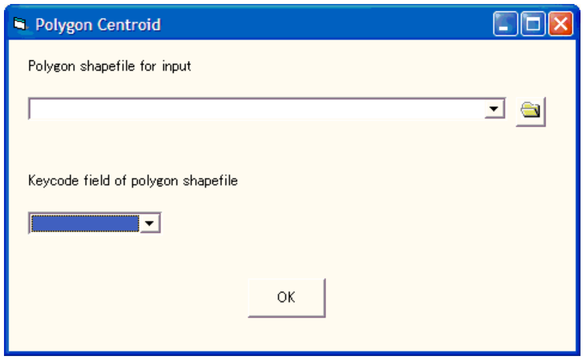
This tool generates a centroid for a polygon.

Inputs

1. Add the polygon shapefile on the project window.
2. Select "Polygon Centroid" in **ShapeEditor** menu.

(1)

(2)



3. Fill in the dialogue box.

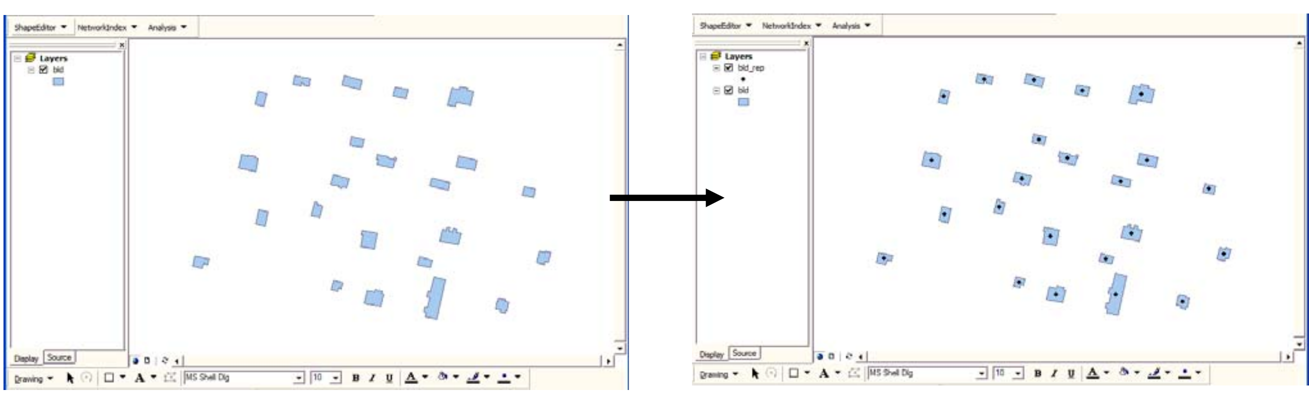
   (1) Select the polygon shapefile.

   (2) Select ID field of the polygon shapefile. This helps connect the output table and the input polygon shapefile.

Output

Point shapefile named "polygon shapefile *.rep*" will be created.

Keycode field selected at step **(2)**	Polygon ID.
X	X coordinate.
Y	Y coordinate.



4.3.3 Grid

This tool divides a polygon into grids of the designated size.

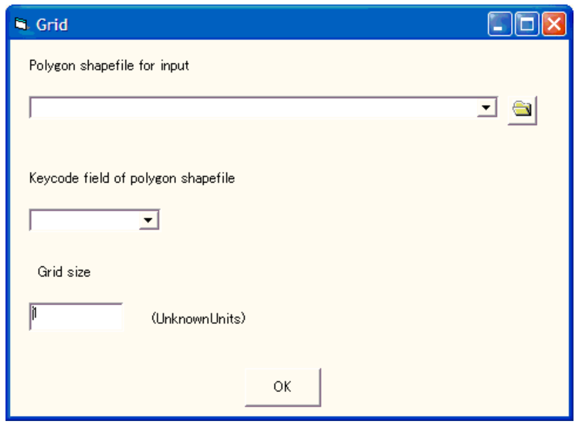
Inputs

1. Add a polygon shapefile on the project window.
2. Select "Grid" in **ShapeEditor** menu.

(1)

(2)

(3)

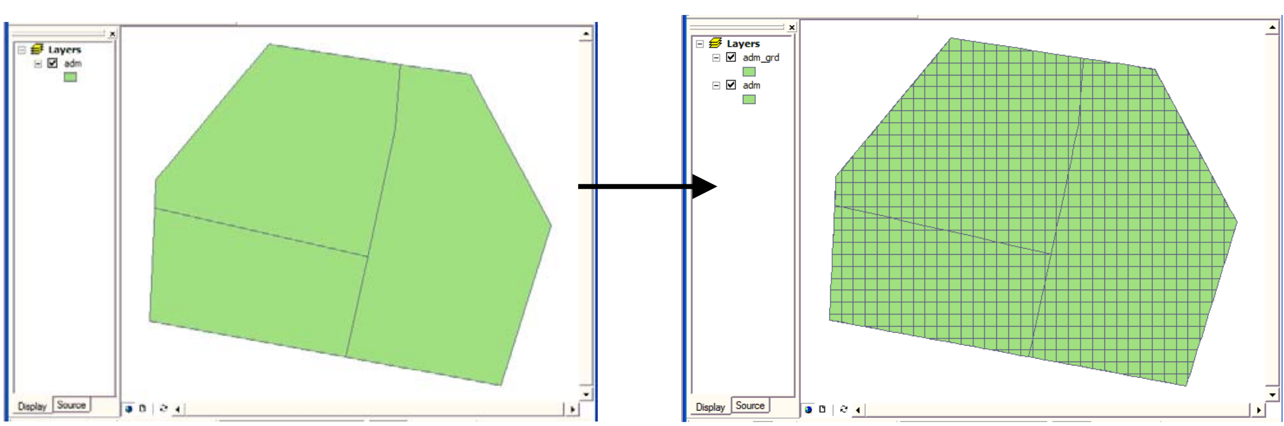


3. Fill in the dialogue box.
   (1) Select the polygon shapefile in the drop down list.
   (2) Select the keycode field, which help connect the input polygon shapefile and the output polygon shapefile.
   (3) Specify the grid size.

Output

A grid polygon shapefile will be created (filename: *input shapefile* _grd).

keycode field selected at step **(2)**	Original polygon ID.
rate	Ratio of the grid area to the original polygon area.



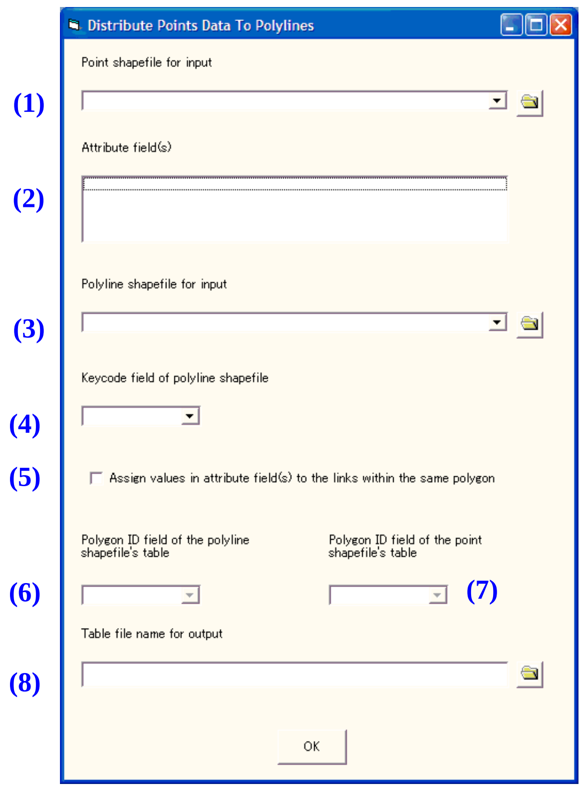
4.3.4 Distribute point data to polylines

This tool assigns attribute values of a point shapefile to a polyline and aggregates them in terms of each line segment.

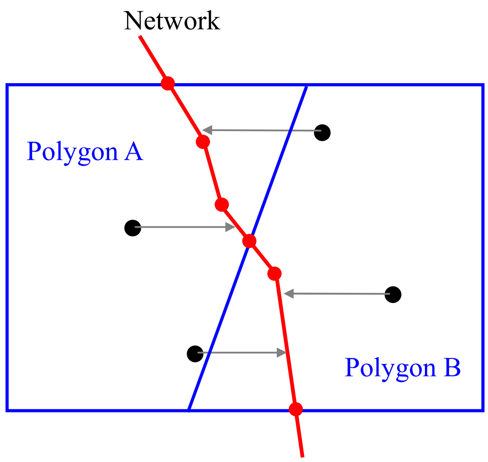
Inputs

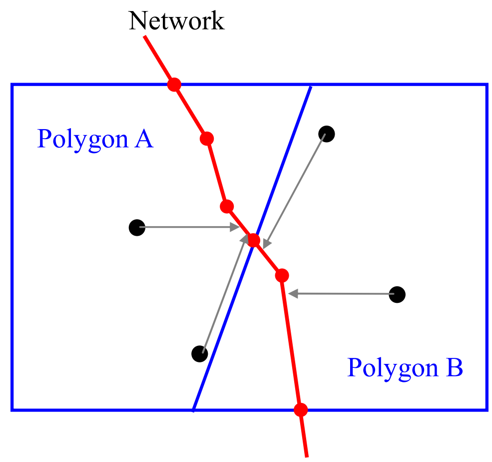
1. Add the following shapefiles to the project window.
   (1) Point shapefile.
   (2) Network polyline shapefile with a field of ID numbers.

2. Select "Distribute Point Data to Polylines" in **ShapeEditor** menu.



3. Fill in the dialogue box.
   (1) Specify the point shapefile.
   (2) Select the attribute field(s) to be assigned to the polygon shapefile.
   (3) Specify the polyline shapefile.
   (4) Select the ID filed of the polyline shapefile to help connect the output table and the input polyline shapefile.
   (5) If you want to assign the point attributes to the link that has the same ID number as the point feature has, even if it is not the nearest link, check in the check box. It means that the point attributes are assigned to the link where both the link and the point feature are located (It is shown in the right figure below).
   If you do not check in the box, point attributes will be assigned to the nearest links. (It is shown in the left figure below).





Note: Leave boxes **(6)** and **(7)** blank if you did not check in the check box at step **(5)**.

(6) Select the field storing the polygon ID in the network polyline shapefile.

(7) Select the field storing the polygon ID in the point shapefile.

Note: Since values in **(6)** and **(7)** are used to connect a point and a polyline which have the same polygon ID, both of the polyline shapefile and the point shapefile should have a field of polygon ID where they belong.
You can make these types of files using “intersect” function in the geoprocessing wizard installed in ArcMap.

(8) Specify the filename of the output table.

Output

A DBF file with the designated filename will be created.

	Keycode field selected at step **(4)**.	Polyline ID.
Multiple fields	Attribute field(s) selected at step **(2)**.	Aggretated values.

4.3.5 Table arrangement

This tool aggregates a table by the designated field.

In the case of the simple example shown below, this tool aggregates records in “Population” that have the same value in “Area_ID”.

Area ID	Population
1	500
1	100
2	200
2	50
3	300
3	400
4	1000

Input table

Area ID	Population
1	600
2	250
3	700
4	1000

Output table

Inputs

1. Select “Table Arrangement” in **ShapeEditor** menu.

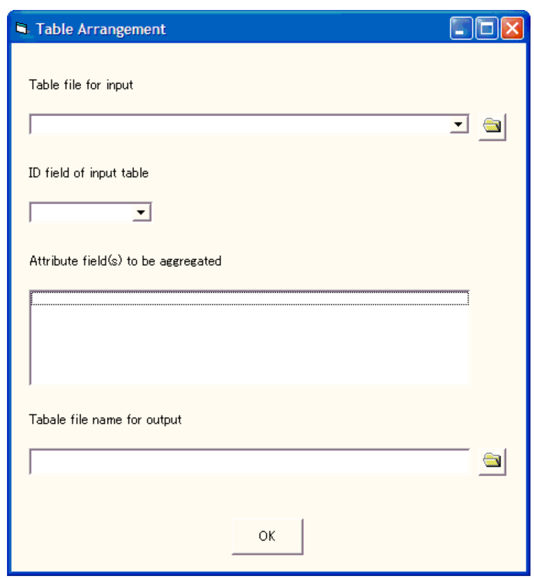
2. Fill in the dialogue box.

   (1) Specify the input file (dbf format).

   (2) Select ID field in the drop down list. Records having the same value in this field become one record in the output file.

   (3) Select the field(s) to be aggregated. Values in the field(s) are aggregated in terms of the field selected at step **(2)**.

   (4) Specify the output file name.



(1)
(2)
(3)
(4)

Output

A DBF file with the designated filename will be created.

Field selected at step **(2)**	ID.
(2)_c	Count number.
Field selected at step **(3)**	Aggregated value.

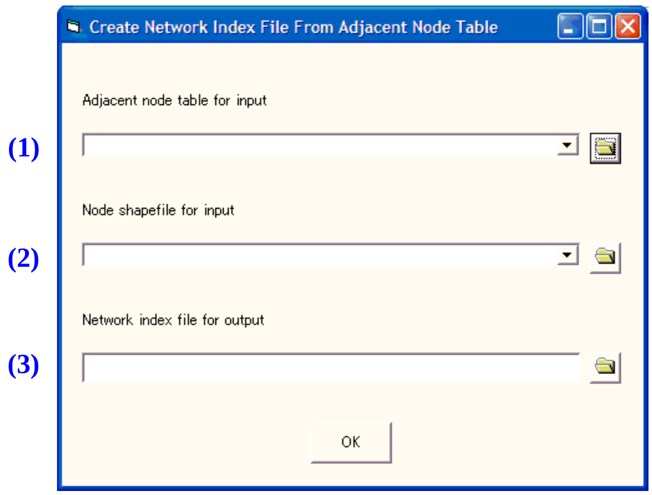
Note: This tool does not work correctly at the present. The bug will be got rid of soon.

4.3.6 Create network index file from adjacent node table

This tool constructs a new polyline shapefile from the existing adjacent node table, the point shapefile and the network index file.

Inputs

1. Select "Create Network Index File from Adjacent Node Table" in **NeworkIndex** menu.



2. Specify three files below.
   (1) Adjacent node table
   (2) Point shapefile
   (3) Network index file

Output

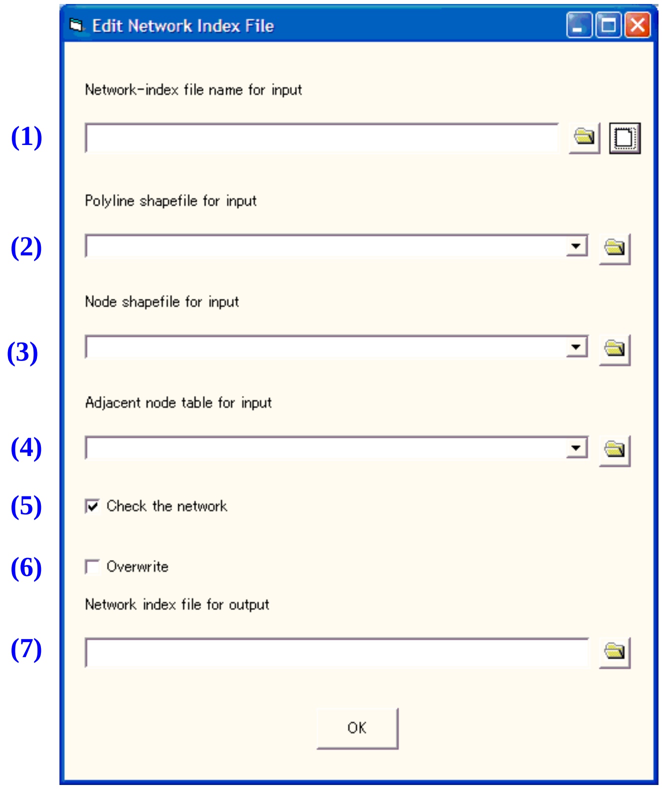
A new polyline shapefile and a network index file will be created.

4.3.7 Edit network index file

This tool changes the combination of the files stored in the network index file.

Inputs

1. Select "Edit Network Index File" in **NeworkIndex** menu.



2. Fill in the dialogue box.

(1) Specify the network index file to be edited.

(2), **(3)** and **(4)** are automatically filled with the contents of the network index file. You can change any of them into a different file.

(5) It is recommended to leave this box checked because it checks up the consistency of the node-link connectivity in the new combination.

(6) If you wish to overwrite the input network index file, check this box.

(7) If you left **(6)** blank, specify the filename of the new network index file.

Inputs

A new network index file "______.nidx" will be created.

5. References

Aho, A.V., Hopcroft, J.E. and Ullman, J.D. (1974) The Design and Analysis of Computer Algorithms, Reading, Massachusetts: Addison-Wesley.

Buxton, T. (1992) GIS Expected to Micromarketing Challenge, GIS World, Vol.5, No.1, pp.70-72.

Egenhofer, M. and Franzosa, R. (1991) Point-Set Topological Spatial Relations, International Journal of Geographical Information Systems 5 (2): pp.161-174.

Kato, T., Sadahiro, U., Shiode, S. and Okabe, A. (2003) Analysis of the spatial distribution of vending machines using GIS, Papers and Proceedings of Geographic Information Systems Association, Vol.12, pp.355-358. (in Japanese)

Morita, M.and Okunuki, K. (2003) A study on the edge effects in analyzing a point pattern on a network, Papers and Proceedings of Geographic Information Systems Association,Vol.12, pp.93-96. (in Japanese)

Morita, M., Okunuki, K. and Okabe, A. (2001) A Market Area Analysis on a Network Using GIS: A Case Study of Retail Stores in Nisshin City, Papers and Proceedings of Geographic Information Systems Association, 10, 45-50. (in Japanese)

Miller, H.J. (1994) Market Area Delineation within Networks using Geographic Information Systems, Geographical Systems, 1(2), 157-173.

Miller, H.J. (1999) Measuring Space-time Accessibility Benefits within Transportation Networks: Basic Theory and Computational Methods, Geographical Analysis, Vol.31, pp.187-212.

Okabe, A., Boots, B., Sugihara, K. and Chiu, S. N. (2000) Spatial Tessellations: Concepts and Applications of Voronoi Diagrams, (2nd edition), Chichester: John Wiley.

Okabe, A. and Kitamura, M. (1996) A Computational Method for Market Area Analysis on a Network, Geographical Analysis, Vol.28, No.4, pp.330-349.

Okabe, A. and Miki, F. (1984) A Conditional Nearest-Neighbor Spatial Association Measure for the Analysis of Conditional Locational Interdependence, Environment and Planning A, Vol.16, pp.163-171.

Okabe, A. and Okunuki, K. (2001) A computational method for estimating the demand of retail stores on a street network and its implementation in GIS, Transactions in GIS, Vol.5, No.3, pp.209-220.

Okabe, A. and Satoh, T. (2006) Uniform network transformation for points pattern analysis on a non-uniform network, Journal of Geographic Systems, 8, 25-37.

Okabe, A. and Yamada, I. (2001) The K-function method on a network and its computational implementation, Geographical Analysis, Vol.33, No.3, pp.271-290.

Okabe, A., Yomono, H. and Kitamura, M. (1995) Statistical Analysis of the Distribution of Points on a Network, Geographical Analysis, Vol.27, No. 2, pp.152-175.

Okabe, A., Okunuki, K. and Shiode, S. (2006) SANET: A toolbox for spatial analysis on a network, Journal of Geographical Analysis, Vol.38, No.1, pp.57-66.

Okabe, A., Okunuki, K. and Shiode, S. (2006) The SANET toolbox: New methods for network spatial analysis, Transactions in GIS, Vol.10, No.4, pp.535-550.

Okano, K. and Okabe, A. (2004) A Method for Analyzing the Spatial Relationship between Two Different Distributions of Line Objects and the Implementation of its Software, Theory and Application of GIS, 12(2), 133-143. (in Japanese)

Shiode, S. and Okabe, A. (2004) Cell Count Method on a Network with SANET and its application, Proceedings of International Conference on Geoinfomatics and Modeling Geographical Systems & Fifth International workshop on GIS, 27-35.

Shiode, S. and Okabe, A. (2004) A network-based spatial analytical method for detecting agglomerations in a point distribution on a network and its implementation, Theory and Applications of GIS, 12(2), 79-87 (in Japanese).

Shiode, S. (2005) Inverse distance weighted method for point interpolation on a network, Theory and Applications of GIS , Vol.13, No.1, pp.33-41 (in Japanese).

Spooner, P., Lunt, I.D., Okabe, A. and Shiode, S. (2004) Spatial analysis of roadside Acacia populations on a road network using the network K-function, Landscape Ecology, Vol.19, No.5, pp.491-499.

Yamada I and Thill J-C (2004) Comparison of planar and network K-functions in traffic accident analysis, Journal of Transport Geography Vol. 12, pp.149-58.