Example Use of SITATION

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Modified for IEOR151, UC Berkeley, Fall 2013
What is SITATION?

- Software to solve location problems
  - Set covering
  - P-median
  - Maximal Covering
  - Uncap. Fixed charge
  - P-center
  - Partial covering P-center
  - Partial covering Set covering
  - Covering-Median Tradeoff
Options include

- Forcing sites in/out of solution
- Different solution algorithms
  - Heuristic
  - Improvement
  - Lagrangian relaxation in branch and bound (*optimal*)
- Mapping
- Reporting
- Manual facility exchanges (for some objectives)
Problem to be solved (P-median)

- Minimize the demand weighted total distance (or average distance)
  - Using 10 facilities
  - To serve the 150 largest demands in the continental US
First step

- Double click on the SITATION Class 58019.exe software. This will load the software. You will see an ABOUT box for about 2-3 seconds followed by the main menu.
Here is the main menu

- First you have to load the dataset you want to load.
- Click on Load Data
To load the data ....

- First tell SITATION what kind of distances you are using
  - Euclidean (straight line)
  - Great Circle (shortest distance on a sphere)
  - Manhattan (right angle)
  - Network

- Click on **GREAT CIRCLE**
Now

- Click on Specify Demand File
Now tell it which file to read

- Either double click on a file name or type the file name into the box labeled File name and then click Open
- Double click on 150city.grt in this example
Basic input file format

Node number   longitude   latitude   demand 1   demand 2   fixed cost   <city name >

Demand 2 is usually ignored, but you can take a weighted sum of Demand 1 and Demand 2 if you want to do so.

1   73.945478   40.670543   7322564   2819401   189600 < New York NY >
Now tell it how to get the distances

- You can either have SITATION compute the distances or you can give it a file name containing the actual distances. Most of the time I let it compute the distances.
- In this example click on **Compute Distances**
Now you are almost done loading the data

- If you want the distances computed in kilometers instead of the default of miles, click on the box asking it to use kilometers. Note that the labels throughout SITATION will still read miles even though distances are in km.
- We will NOT do this in this example
Also note

- SITATION tells you the name of the file it will read and the number of nodes to be read.
Finally,.....

To actually compute the distances and get back to the main menu, simply click on Exit and Load Data.
But first …

- SITATION will ask if you want to save the distances. You almost never do, so just click No
Now you are back at the Main Menu

- You must now specify the coverage distance and a cost per mile even if the model to be run does not call for these values. They are used for reporting purposes.
- Click on Set Parameters.
Now …

- Type in a coverage distance (e.g., 300)
- And a cost per mile (e.g., 1)
Now

- If you notice the **Done and Run** box is now available. Clicking this will allow you to go back to the Main Menu. You can also force sites in or out of the solution using the **Force Nodes** option. We will not do that in this example.
- Click **Done and Run**
Also force nodes into/out of solution

<table>
<thead>
<tr>
<th>Node</th>
<th>City</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New York</td>
<td>NY</td>
</tr>
<tr>
<td>2</td>
<td>Los Angeles</td>
<td>CA</td>
</tr>
<tr>
<td>3</td>
<td>Chicago</td>
<td>IL</td>
</tr>
<tr>
<td>4</td>
<td>Houston</td>
<td>TX</td>
</tr>
<tr>
<td>5</td>
<td>Philadelphia</td>
<td>PA</td>
</tr>
<tr>
<td>6</td>
<td>San Diego</td>
<td>CA</td>
</tr>
<tr>
<td>7</td>
<td>Detroit</td>
<td>MI</td>
</tr>
<tr>
<td>8</td>
<td>Dallas</td>
<td>TX</td>
</tr>
<tr>
<td>9</td>
<td>Phoenix</td>
<td>AZ</td>
</tr>
<tr>
<td>10</td>
<td>San Antonio</td>
<td>TX</td>
</tr>
<tr>
<td>11</td>
<td>San Jose</td>
<td>CA</td>
</tr>
<tr>
<td>12</td>
<td>Baltimore</td>
<td>MD</td>
</tr>
</tbody>
</table>

- Disallow All Nodes
- Permit All Nodes
- Force Site(s)
- Unforce Site(s)
- Exclude Site(s)
- Allow Site(s)

- Write Status to Disk
- Read Status from Disk

150 Allowed Nodes
0 Excluded Nodes
0 Required Nodes
0 Initialized Nodes
Before getting back to the Main Menu

- SITATION tells you how large the cover list is. This is just for information purposes and you can usually ignore it.
- Click OK
SITATION will let you run either single or multiple objective (Tradeoff Curve) problems. We want a single objective problem (the P-median problem) so click on Run Models.
First you must tell SITATION which problem to solve

- Click on the problem to be solved. In our case we want the P-median problem
Problem available: P-Median

**P-median** – minimize the demand weighted total distance by locating a fixed number of facilities

**IP Formulation**
- \( h_i \): demand at customer \( i \)
- \( D_{ij} \): distance between customer \( i \) and site \( j \)
- \( P \): number of facilities
- \( x_j \): 1, if we locate at site \( j \); 0, otherwise
- \( y_{ij} \): 1, if customer \( i \) is served by site \( j \); 0, otherwise
P-Median Problem

IP Formulation

\[
\min \sum_{j} \sum_{i} d_{ij} h_i y_{ij}
\]

\[st.\]

\[\sum_{j} x_{j} = p\]

\[y_{ij} \leq x_{j}, \forall i, j\]

\[\sum_{j} y_{ij} = 1, \forall i\]

\[x_{j}, y_{ij} \text{ binary}\]
Other Problems available

- **Maximal covering** – maximize the number of covered demands in the specified coverage distance with a fixed number of facilities

- **Uncapacitated fixed charge** – minimize the sum of the fixed costs and demand weighted transport costs
And

- **Set covering** – find locations of the minimum number of facilities needed to cover all demands within the specified coverage distance

- **P-center** – find locations of a user-specified number of facilities to minimize the coverage distance needed to cover all demands

- **Partial set covering** – same as set covering but the model can exclude (not cover) a user-specified number of nodes or fraction of the total demand
And

- **Partial P-center** – like the P-center except that the model will allow a user-specified number of nodes or fraction of demand to be outside the reported coverage distance

- **Inventory/Location (SCD) model** – find the DC locations, market assignments to DCs and DC inventory policy to minimize fixed DC costs, inventory costs at the DC, shipment costs to markets and shipment costs from plants to DCs
How do you want to solve the problem?

- You must now tell SITATION which of several algorithms to use to solve the problem. In general, you should use **Lagrangian Relaxation**. This embeds LR in branch and bound and guarantees optimal solutions.
Specify the number to locate

- Tell the model how many sites to locate. For some models (e.g., the uncapacitated fixed charge problem, specifying –1 tells SITATON to find the best number)
- Type 10 in the indicated box
Now...

- You can set the parameters of the Lagrangian Relaxation algorithm. This is a bit complex and we will **skip** it in this example.
- Do NOT click on **View and Set Lagrangian Options**
We are now ready to run the model

By clicking on **Quit and Run** you ask SITATION to solve the problem
Lagrangian Progess Form

This form tells you information about the progress of the algorithm including the bounds on the solution.
The total number of iterations

<table>
<thead>
<tr>
<th>Locations</th>
<th>B+B Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lag. Iterations</th>
<th>B+B Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Upper Bound</th>
<th>Lower Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,362,939,473.0</td>
<td>3,268,219,622.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>400.6682955</td>
<td>1.0000000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failures</th>
<th>Step Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>17,412,498.129</td>
</tr>
</tbody>
</table>

EXCHANGE ON Branch and Bound Tree Below

Forced Nodes Info

Time So Far

0.27

% of tree explored

0%
Information on the branch and bound tree
Which nodes are forced in (+) out (-) and undecided (0) at this point in the branch and bound algorithm.
And …

- What percent of the branch and bound tree has been explored so far

<table>
<thead>
<tr>
<th>Locations</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iterations</td>
<td>101</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>16,362,939,473.0</td>
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<tr>
<td>Failures</td>
<td>5</td>
</tr>
<tr>
<td>Step Size</td>
<td>17,412,498.129</td>
</tr>
</tbody>
</table>

**Lagrangian Progress Form MEDIAN OBJECTIVE**

- B+B Nodes: 1
- Lag. Iterations: 101
- B+B Level: 0

**Branch and Bound Tree Below**

EXCHANGE ON

**Forced Nodes Info**

Time So Far: 0.27

% of tree explored: 0%
When the algorithm finishes ...

- You should see this information box.
- Click OK
You can now

- Display the results
- Map the results
- Manually modify the results for some objectives
First

- We will display some results. Click on Display Results
You can now

- Display a lot of results.
- First click on Basic Inputs and Outputs
This summary shows

- A summary of the basic model inputs
- Model outputs including the problem and algorithm being solved, statistics on how long it took to solve it, and the objective function values
Once you have studied this report click **Cancel** to return to the menu of reports.
Now see where you locate

- Click on Extended Summary to see where SITATION located facilities
This tells you where you locate facilities, the number of covered demands, the % of demands covered, the average weighted distance, and the total cost.
And the verdict is…

- Note that the average weighted distance should be 127.13 miles if you solved this correctly
And now…

After studying this report click Cancel
Show the number of nodes covered X times

<table>
<thead>
<tr>
<th>BASIC SUMMARY TABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Inputs and Outputs</td>
</tr>
<tr>
<td>Forced Nodes</td>
</tr>
<tr>
<td>Location Summary</td>
</tr>
<tr>
<td>Extended Summary</td>
</tr>
<tr>
<td>Tradeoff Curve</td>
</tr>
<tr>
<td>Uncovered Node Summary</td>
</tr>
<tr>
<td>Assigned Demand Summary</td>
</tr>
<tr>
<td>Coverage Summary</td>
</tr>
<tr>
<td>Number of Times Covered</td>
</tr>
<tr>
<td>Graph Tradeoff Curve</td>
</tr>
<tr>
<td>Dominated Nodes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXTENDED SUMMARY TABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Save Solution to Disk</td>
</tr>
<tr>
<td>Save Tradeoff Curve</td>
</tr>
<tr>
<td>Save Mapping Data</td>
</tr>
<tr>
<td>Assignment to Sites</td>
</tr>
<tr>
<td>Fixed Costs</td>
</tr>
<tr>
<td>Node to Facility Report</td>
</tr>
<tr>
<td>COver Lists</td>
</tr>
<tr>
<td>Utilization of Facility Sites</td>
</tr>
<tr>
<td>Require Assignments</td>
</tr>
</tbody>
</table>

- Click on Number of Times Covered
This report shows

- That in this solution 25 nodes (and 6,454,361 demands) are not covered at all, 115 nodes are covered once and 10 are covered twice.
And now

When you are done looking at this click Cancel

<table>
<thead>
<tr>
<th>No. Times</th>
<th>No. Nodes</th>
<th>Number of Demands</th>
<th>Percent Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25</td>
<td>6,454,361.000</td>
<td>11.0906</td>
</tr>
<tr>
<td>1</td>
<td>115</td>
<td>48,981,601.000</td>
<td>84.1658</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2,760,568.000</td>
<td>4.7435</td>
</tr>
<tr>
<td>TOTAL</td>
<td>150</td>
<td>58,196,530.000</td>
<td>100.0000</td>
</tr>
</tbody>
</table>

88.9094 PERCENT OF DEMANDS COVERED
Now find out how demands are assigned to facilities

- Click on AssignMent to Sites
Assignment to Sites

This shows which facility is assigned to serve each demand area, the distance between them, whether the demand area is covered, the demand there, etc.
As well as the maximum assigned distance and the total demand weighted distance
Go back ....

- Click on **Cancel** to go back to the reports menu
There are many other reports, graphs (for some problems) and options to save results. Experiment with them. They should be self explanatory.
Go back to the Main Menu

- To get back to the main menu, click Quit (return to main menu)
Now we can Map the solution

- Click on Map Results
Tell it what the border file is

- If you have a file giving the coordinates of the border of the region under study, click Yes; otherwise click No
- Click Yes now
Tell it which file to read

- Double click on the name of the desired border file
Here is the map

- This shows the locations of the facilities and the demand nodes assigned to each facility.
- Click on option 2 Show Names to see the facility names.
Here we are

- Here are the names. Other options let you change what is displayed on the map.
To zoom in, drag the mouse from top left to bottom right of the region to zoom on.
Click on **Show all names** to label all sites
Here are all the city names

- Cities connected to facilities by red lines are within the coverage distance.
- Cities connected to facilities by blue lines are further than the coverage distance.
Zoom out

To return to the original map, drag a box from the lower right to the upper left.
Click on **Blank** to get rid of the city names
Now see other maps

- Click on % Demand to see the relative demands
Map of relative demands

- Note the high bars at New York and Los Angeles
- Now click @ Coverage
This map draws a line between any pair of cities that are within the coverage distance of each other.
Click on $\textbf{Normal}$ to see the map of the solution again.
Go back again…

- Click on Return to Main Menu to go back to the Main Menu
Now try exchanging sites

- Click on Exchange Sites to manually change the solution.
- Note that this option is not available with all objectives.
Exchange sites

- In this example, we will see what happens if we locate in Philadelphia instead of New York
- Click Exchange 2 Sites
Add Philadelphia

Click on Philadelphia
Tell SITATION to add it

<table>
<thead>
<tr>
<th>List of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>6</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>7</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>8</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>9</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>10</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>11</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>12</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>13</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>14</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>15</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>16</strong> ALLOWED</td>
</tr>
<tr>
<td><strong>17</strong> ALLOWED</td>
</tr>
</tbody>
</table>

**Message Area**

- **Click on** Pick node to **Add**
Tell SITATION which node to remove

- Highlight New York (it should already be highlighted)
Tell it to delete New York

- Click on Pick node to Drop
Now

- SITATION will show you a message telling you the impact of the change (in this case, among other impacts, the average distance will go up by 6.45 miles)
- Tell SITATION whether you want to make the change
- Click Yes in this case
Now

- Look carefully and there is now a facility in Philadelphia and no facility in New York
- Click Close to go back to the Main Menu
You could now

- Display the results of these manual changes or map the new solution, etc.
- But we will skip all that. You should now know how to do all of that.
Now we can get out of SITATION

- Click Exit SITATION
To prevent you from inadvertently leaving before you want to, SITATION asks you to confirm that you really want to exit.

Click **Yes**
And finally

- Click OK to return to Windows
SITATION is (hopefully)

- Relatively easy to understand if you know a bit about location models.
- Relatively bullet proof. It should be very hard to crash it.
- Try other options on your own
And note

- You can print any of the reports, graphs or maps just by clicking on the appropriate Print button.
Enjoy

- Have fun using SITATION. Experiment with
  - Forcing facility sites into or out of the solution
  - Other objective functions
  - Etc.
Exercise

- You are working for a global chain company which just starts to expand their market into USA. They are planning to build 10 plants in USA. There are 150 candidate cities to choose from. You are given the demand information at each city (Please see 150city.grt file.) The current goal of the company is to minimize the demand weighted total distance since transportation expenses are the key factor to the company profits. Assume now you want to exclude New York and Los Angeles as candidate sites of your facility due to the consideration of the high probability of natural disaster. Please use Sitation software to find the best locations and show the results in map.