Facilities Location Project

George Barmakian
Jenine Davignon
Adam Ginsburg
Sevag Khatchadourian
Bethany Quigley
Acknowledgements

SSYMCA

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- VP of Operations, Natalie Sheard
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Northeastern Faculty

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The purpose of this project was to complete a facilities location study to determine future expansion strategies for the South Shore YMCA (SSYMCA). The South Shore and Cape Cod regions consist of a large population with limited access to existing YMCA services. The SSYMCA desires an efficient methodology to meet the needs of all potential members.
YMCA Background

- Largest not-for-profit organization in America
- 2,617 locations nationwide, 20.2 million members
- Community Based and Driven
- Variety of Programming for Every Age
- Helping Raise America's Children
- Beyond Health and Fitness
- More than a Gym - a Community
Present Locations

- Mill Pond Branch (Hanover)
- Quincy Facility
- Barnstable Branch
- Plymouth Branch (planned facility)
Needs & Requirements

- Identify target customers and areas of need
- Determine relative location and accessibility
- Minimize cannibalization between facilities
- Develop long term strategic vision
- Activities and services
Data Collection

- Determining potential locations
  - Accessibility
    - Reduce distance between potential facilities and demands
  - Traffic data
    - Identified heavy traffic areas
  - 15 minute drive time requirement
    - Validated by membership data and survey
- Public transportation
  - Insignificant presence in region
Data Collection

- Defining demand
  - Census — Segmenting population into census tracts
  - SEER/PMA Studies — Establishing market penetration
- Survey — Reasons for joining
- Member Database — Activity enrollment
Research

• Types of Models
  • Set covering – Minimize facilities to cover all demand
  • Accessibility – Minimize distance between facility and demand

• Characteristics of the Model
  • Network vs. planar mapping
  • Capacitated vs. uncapacitated constraint
  • Deterministic vs. probabilistic input data
  • Inelastic demand, static locations
  • Single vs. multiple facility model
  • Output vs. input number of facilities
Bi-Objective Minimization Model

Inputs:
- \( w \) = scaling factor
- \( h_j \) = demand at node \( j \)
- \( d_{ij} \) = distance from candidate site \( i \) to demand node \( j \)

Decision Variables:
- \( X_i \) = candidate site \( i \)
- \( Y_{ij} \) = demand node \( j \) assigned to candidate node \( i \)

Minimize Objective Function:

\[
Z = \sum_i wX_i + \sum_i \sum_j h_j d_{ij} Y_{ij}
\]  
(1)
**Bi-Objective Minimization Model**

Minimize:

\[
Z = \sum_{i} wX_i + \sum_{i} \sum_{j} h_j d_{ij} Y_{ij}
\]  

(1)

Subject to:

\[
\sum_{i} Y_{ij} = 1 \quad \forall j
\]  

(2)

\[
Y_{ij} - X_i \leq 0 \quad \forall i, j
\]  

(3)

\[
\sum_{j} Y_{ij} h_j \leq c_i X_i \quad \forall i
\]  

(4)

\[
X_i = 0, 1 \quad \forall i
\]  

(5)

\[
Y_{ij} = 0, 1 \quad \forall i, j
\]  

(6)
Implementing the Model

Automation and Integration:

• Excel-Data Management
• Lingo-Optimization Application
• MapPoint-Data Mapping Software
Model Results

- Four Approaches
  1. Maximized Set Covering Approach
  2. Weighted Set Covering Approach
  3. Weighted Accessibility Approach
  4. Maximized Accessibility Approach

- Activity Recommendations
  - Compared to existing regional facilities
  - General suggestions of activities at each facility
Maximized Set Covering Approach

- Minimize number of facilities used to cover demand

- Locations
  1. Marshfield
     - Route 3 & Pine Street
  2. Harwich
     - Route 6 & Route 137
Weighted Set Covering Approach

- Reduce number of facilities while giving some weight to accessibility

- Locations
  1. Marshfield
     - Route 3 & Pine Street
  2. Falmouth
     - Sandwich Rd & Hayway Rd
  3. Harwich
     - Route 6 & Route 137
Weighted Accessibility Approach

- Maximize accessibility to demand nodes with some weight to minimizing facilities

- Locations
  1. Kingston
     - Route 27 & Route 106
  2. Cohasset
     - Route 3A & Beechwood St
  3. Falmouth
     - Sandwich Rd & Hayway Rd
  4. Harwich
     - Route 6 & Route 137
Maximized Accessibility Approach

- Maximize accessibility of facilities to demand nodes

- Locations
  1. Kingston
     - Route 27 & Route 106
  2. Falmouth
     - Sandwich Rd & Hayway Rd
  3. Harwich
     - Route 6 & Route 137
  4. Scituate
     - Route 3A & Henry Turner Bailey Rd
  5. Randolph
     - Route 139 & Mill Street
Projected Membership & Recommended Services

- Falmouth

<table>
<thead>
<tr>
<th>Suggested Activities</th>
<th>Total</th>
<th>6054</th>
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<tbody>
<tr>
<td><strong>Adult Fitness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatics</td>
<td>Age</td>
<td>Percentage</td>
</tr>
<tr>
<td>0 to 9</td>
<td></td>
<td>11.4%</td>
</tr>
<tr>
<td>Arts &amp; Humanities</td>
<td>10 to 19</td>
<td>12.3%</td>
</tr>
<tr>
<td>Family</td>
<td>20 to 29</td>
<td>7.5%</td>
</tr>
<tr>
<td>Teen</td>
<td>30 to 39</td>
<td>13.6%</td>
</tr>
<tr>
<td>Teen Fitness</td>
<td>40 to 49</td>
<td>15.4%</td>
</tr>
<tr>
<td>Vacation Camp</td>
<td>50 to 59</td>
<td>13.5%</td>
</tr>
<tr>
<td>Youth Sports/Fitness</td>
<td>60 to 69</td>
<td>11.5%</td>
</tr>
<tr>
<td></td>
<td>70 to 79</td>
<td>9.9%</td>
</tr>
<tr>
<td></td>
<td>80 and up</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

- Recommended Services
- Projected Membership Demographics
- Relative Facility Size
Sensitivity Analysis

Maximize Set Covering

Maximize Accessibility

2 Facilities
MARSHFIELD Rte. 3 & Pine St.

3 Facilities
MARSHFIELD Rte. 3 & Pine St.

4 Facilities
MARSHFIELD Rte. 3 & Pine St.
FALMOUTH Sandwich Rd. & Hayway Rd.

5 Facilities
MARSHFIELD Rte. 3 & Pine St.
FALMOUTH Sandwich Rd. & Hayway Rd.
HARWICH Rte. 6 & Rte. 137

COHASSET Rte. 3a & Beechwood St.
KINGSTON Rte. 27 & Rte. 106
FALMOUTH Sandwich Rd. & Hayway Rd.
HARWICH Rte. 6 & Rte. 137

RANDOLPH Rte. 139 & Mil St.
SCITUATE Rte. 3a & Henry Turner Bailey Rd.
KINGSTON Rte. 27 & Rte. 106
FALMOUTH Sandwich Rd. & Hayway Rd.
HARWICH Rte. 6 & Rte. 137

Trade-off

2 Facilities
3 Facilities
4 Facilities
5 Facilities
Recommended Expansion

- **Kingston**

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<tr>
<td>Family</td>
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<td>Gymnastics</td>
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<tr>
<td>Teen</td>
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<tr>
<td>Age 0 to 9</td>
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<td>14.6%</td>
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<td>17.0%</td>
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</tr>
<tr>
<td>Age 80 and up</td>
<td></td>
<td>4.0%</td>
</tr>
</tbody>
</table>

- Greatest need
- Between Hanover and Plymouth facilities
- Full-scale facility
- Minimal cannibalization potential
Conclusions

- Suggested new facility in Kingston, MA
- Falmouth & Harwich facilities for underserved Cape Cod demand
- Strong cannibalization concerns for Cohasset/Scituate and Randolph regions
Future Considerations

- Computational Efficiency and Tools
  - Software selection

- What-if Scenarios
  - More usability in model

- Interchangeability & Scalability
  - Transfer of model to any region
Questions?
Bi-Objective Minimization Model

Minimize:

\[
Z = \sum_{i} wX_i + \sum_{i} \sum_{j} h_j d_{ij} Y_{ij} \quad (1)
\]

Subject to:

\[
\sum_{i} Y_{ij} = 1 \quad \forall j \quad (2)
\]

\[
Y_{ij} - X_i \leq 0 \quad \forall i, j \quad (3)
\]

\[
\sum_{j} Y_{ij} h_j \leq c_i X_i \quad \forall i \quad (4)
\]

\[
X_i = 0, 1 \quad \forall i \quad (5)
\]

\[
Y_{ij} = 0, 1 \quad \forall i, j \quad (6)
\]
## Weight Factor Table

<table>
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<tr>
<th>Weight Coefficient</th>
<th>Number of Additional Facilities</th>
<th>Estimated Solver Run Time</th>
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<tr>
<td>0-40</td>
<td>13</td>
<td>0 - 5 sec</td>
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<tr>
<td>40-85</td>
<td>12</td>
<td>0 - 5 sec</td>
</tr>
<tr>
<td>85-135</td>
<td>11</td>
<td>0 - 5 sec</td>
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<tr>
<td>135-215</td>
<td>10</td>
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<tr>
<td>215-230</td>
<td>9</td>
<td>5 - 10 sec</td>
</tr>
<tr>
<td>230-265</td>
<td>8</td>
<td>5 - 10 sec</td>
</tr>
<tr>
<td>265-335</td>
<td>7</td>
<td>5 - 15 sec</td>
</tr>
<tr>
<td>335-400</td>
<td>6</td>
<td>5 - 15 sec</td>
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<tr>
<td>400-700</td>
<td>5</td>
<td>20 sec - 2 min</td>
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<td>700-1375</td>
<td>4</td>
<td>50 sec - 6 min</td>
</tr>
<tr>
<td>1375-1550</td>
<td>3</td>
<td>5 - 8 min</td>
</tr>
<tr>
<td>1550-4000</td>
<td>2</td>
<td>45 sec - 5 min</td>
</tr>
<tr>
<td>&gt;4000</td>
<td>1</td>
<td>0 - 50 sec</td>
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</table>
YMCA Demographic Survey

The South Shore YMCA is working with a group of five Northeastern University Engineers on their Senior Capstone Project. They are looking to collect data from real YMCA members as to what motivated you to join the YMCA instead of another organization.

Please take a moment to help these students with their project.

Age: _____ Gender: M F (please circle one)

Town you live in: ___________________________

Town you work in: __________________________

Years as a YMCA Member: __________

Type of Membership: Household Adult Junior Senior Youth (please circle one)

Where do you travel from most frequently to use the YMCA?

School Work Home Other: __________
(please circle one)

How long do you travel to get to the YMCA: (please circle one)

0-10 minutes 11-20 minutes 21-30 minute 30+ minutes

Primary reason for joining YMCA: (please check as many as apply)

___ Family Friendly
___ Nearby/Accessible
___ Affordability
___ Other: __________________________

Program/Service you use the most at the YMCA: