Liturgical Ministry Scheduling

By

Elise M Balhoff
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Department of Computer and Mathematical Sciences
University of Houston – Downtown

Faculty Advisor:
Dr. Timothy Redl

Committee Member:
Dr. Ali Berrached

Committee Member:
Dr. Lin Hong

Committee Member:
Dr. Shengli Yuan
Acknowledgements

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Abstract

This semester concentrated on the use of graph algorithms and coloring to design and implement a scheduling algorithm based on a variety of constraints. The implementation was accomplished using Visual Basic 2005 Express Edition and Microsoft Access 2003.
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Introduction

Scheduling liturgical ministers for a parish involves assigning ministers to masses on a quarterly or three month schedule. Certain preferences, such as Mass time of each minister, as well as keeping family members serving together on the same weekends, must be taken into account as each weekend’s ministers are scheduled. There are five different ministries at Saint Bartholomew the Apostle Roman Catholic Church: altar servers, lectors, ushers, greeters, and extra-ordinary ministers (EOMs). The ministries are scheduled in order of difficulty, beginning with the altar servers. Since only one Mass time is scheduled at a time, the Mass times are scheduled in order of greatest to least number of available ministers, so that extra ministers can help out other Masses as needed.

The primary focus of this project was the scheduling of the altar servers. This paper focuses on the algorithm developed to accomplish this scheduling.
Altar Servers

The scheduling of the altar servers is done using a three-tiered algorithm. The first and third tiers utilize graph coloring. In a given graph, two nodes (vertices) are connected by an edge if they are in conflict with one another; the graph is then colored such that any two nodes connected by an edge cannot be the same color. Also, we desire that a minimum number of colors be used; in order to best achieve this result, vertices are colored in order of decreasing degree. After the graph is colored, any two nodes that are the same color are compatible.

![Graph Coloring](image)

The specific coloring algorithm used is the Smallest-First Greedy Algorithm. This algorithm facilitates the goals minimal colors and even distribution of coloring because it chooses the color of a vertex by:

1. Using a color that has already been used as long as there is no edge between the vertices.
2. Otherwise, it uses a new color.
3. If there are two or more color choices for a given vertex, it chooses the color that has been used the least (in order to achieve even distribution).

The vertices are colored in order of decreasing degree. In other words, weekends with the most conflicts are colored first since they are the most difficult to color.
Assign Servers to Groups

Altar servers are assigned to groups of 3, 4, or 5, depending on the number of available servers at that Mass time. The size of the groups is decided as follows (where n is the number of available servers):

- if $n \leq 9$
  - then 3 groups of 3
- if $10 \leq n \leq 12$
  - then 4 groups of 3
- if $n = 13$
  - then 3 groups of 3, 1 group of 4
- if $n = 14$
  - then 2 groups of 3, 2 groups of 4
- if $n = 15$
  - then 2 groups of 5, 2 groups of 3
- if $15 \leq n \leq 20$
  - then 4 groups of 5

Extra servers needed to fill the groups for a given Mass will be borrowed randomly from another group at that Mass time or borrowed from another Mass time. Twenty servers constitutes a full roster; if a Mass time has more than twenty servers, the program will schedule any extra servers at their second preferred Mass time or at the Mass time with the most need.
Altar servers are assigned to groups in the following order:

- Servers with head server qualifications
- Siblings of head servers
- Other family members
- New servers
- All other servers

This order meets the need to have at least one head server at every Mass, and to keep families together so that they can all serve on the same weekends.

In the case of the 5:00 PM Saturday and 5:00 PM Sunday Masses, Saint Bartholomew currently has 11 altar servers for each Mass. Also for each of these Masses, 3 of the 11 altar servers are head servers. Using the algorithm for group sizes discussed above, each of these Masses would have 4 groups, each of which would contain 3 altar servers. Since there are only three head servers, the head servers would each serve an extra Sunday once per schedule.

In the case of the 7:30 AM Sunday Mass, Saint Bartholomew currently has 15 altar servers. Once again referencing the algorithm for group sizes, this Mass would have 4 groups: 2 groups would have 5 altar servers and 2 groups would have 3 altar servers. These groups total 16 altar servers. The extra altar server will be assigned randomly each month from the other 3 groups.

In the case of the 9:00 AM Sunday Mass, there is a full house: there are 20 altar servers available at this Mass. Consequently, there are 4 groups, each of which contains five altar servers. This Mass is currently the easiest Mass to schedule because it has an ideal number of altar servers and because, unlike the 5:00 Masses, there is no shortage of head servers: there are 8 head servers currently.
In the case of the 10:45 AM Sunday Mass, there are 20 servers as well. This Mass therefore also has 4 groups of 5 altar servers. However, there are only 3 head servers. As a result, each head server must serve one extra weekend per schedule. This requirement means that there is an extra altar server: there are 17 regular altar servers available to fill 16 spots. In order to ensure that each altar server serves at least once per month, the members of the fourth group will rotate and the odd man out each month will serve either at their second choice Mass or at the Mass with the most need.

Example groups for each Mass time are shown in the Appendix. Unknown simply means that an altar server either from that Mass time or another Mass time will be pulled each month to help out in that group.

Assign Weekends

Once the size of groups is determined and altar servers are assigned to each group, each group is assigned a color. Graph coloring is then used to schedule each group for a set of weekends over the 3-month period. There are three requirements that must be met in constructing and coloring this graph: there are only as many colors used as there are groups, altar servers may not serve on back-to-back weekends, and groups may only serve once per rotation (for example, if there are 4 groups, each group may only serve once per calendar month.

For these graphs, a vertex represents a particular weekend. The program generally will compute a three month schedule, so the graph would consist of approximately twelve vertexes or nodes, one representing each weekend over the 3-month cycle. An edge between two vertices indicates that the two corresponding weekends cannot be assigned to the same group of altar servers. For any given color, no two vertices of that color may be connected by an edge;
therefore a group of altar servers may be assigned to all weekends of a certain color without conflict.

Each Mass should have 3 or 4 groups of altar servers to be scheduled so as not to overburden their commitment, while ensuring that they serve at least once a month. The following are illustrations of the colored schedules for Mass times with 3 and 4 groups of altar servers, respectively:

*figure 2: Weekend Coloring for 3-group Masses*

*figure 3: Weekend Coloring for 4-group Masses*
Each group is scheduled to serve the set of weekends corresponding to its color. For example, if there are four groups and the program colors the weekends as shown in figure 3, then one of the groups would be colored yellow and would serve on weekends 2, 7, and 12.

At present, all Masses have 4 groups of altar servers and require a coloring similar to figure 3.

**Assign Tasks within Each Group**

In a three person group, there is one head server and two candle bearers. In a four or five person group, the extra altar servers are gift escorts. The head server must be qualified to serve that position. Additionally, new servers should serve as gift escorts at their first Mass and as candle bearer with a more experienced server at their second Mass. All of this can be achieved using graph coloring:

New server(s) are assigned to their tasks first, followed by the head server(s), and then the other servers are assigned to the remaining positions. It was already determined in tier 1 (*Assign Servers to Groups*) that each group has at least one head server and no more than three
new servers. If there are three new servers in a group, one will have to serve candle bearer, however otherwise this should not be the case.

Each altar server is assigned to tasks within a group for which they are qualified, as shown in the bars to the right of figure 4. For example, new servers ought to serve as gift escort for their first Mass, therefore the only color to which they may be assigned is green. New servers serving for the second time may serve as gift escort, preferably they should serve as candle bearer with a more experienced server; for this reason, these servers should be assigned orange if possible or otherwise green. They cannot serve as the yellow candle bearer position simply because this color ensures that one candle bearer will be experienced (not new).

Head servers may serve as any of the positions, but should be assigned according to decreasing task difficulty: head server, candle bearer, and then gift escort, as evidenced by the head server bar in figure 4: red, yellow, orange, and then green. Regular servers then are assigned to the remaining tasks.

If a Mass time has any extra servers, they are put into a pool to be used at another Mass time. This process is completed for each Mass time. Other ministries can then be scheduled in order of difficulty, while keeping families together (for example, if the parents are lectors and the children are altar servers).
Database

I used an Access 2003 database as the back-end storage for my program. This database has nine entity sets, represented as tables. Each type of ministry has its own entity set, but are also part of a larger entity set called Minister. Each minister has a family id number and this number aids my search for family members. Each family id number in the Families entity set has attributes which tell how many members are in each ministry. Therefore, when I am scheduling, I can check to see how many people in that family participate in the ministry that I’m scheduling and how many participate in ministries that have already been scheduled. This information helps when trying to keep families together on the same weekends.

Additionally, I added practical functionality to the program via the database. The database stores contact information, as well as information about special Masses. My goal is that this information will be more easily viewable and maintainable via this program.
Future Work

One of my primary goals in the immediate future is extendibility. Currently only the altar servers have been figured into the scheduling algorithm. I would like to schedule the rest of the ministries (lectors, EOMs, ushers, and greeters) in order of difficulty, which I have yet to determine. These ministries would first check to determine whether any family members had been scheduled in previously scheduled ministries. These ministers would then be assigned to the same weekends. Groups would then be formed to fill in the remaining weekends approximately according to the first two tiers of the altar server scheduling algorithm. As far as I understand, there is no need to schedule tasks within the other ministries.

Additionally, I plan to convert the application (which is currently a visual basic.net windows application) to a web interface. This would make the current schedule more easily viewable and updatable in case of changes and would make the contact and special Mass functions of the application more easily maintainable.

Finally, I hope to set up some sort of a reminder system to remind ministers of their commitments, particularly when they have signed up for special Masses.
References


- Culberson, Joseph. *Graph Coloring Programs*. University of Alberta.  
Appendix: Assign Altar Servers to Groups

5:00 Mass (Saturday)
Head Servers: Laura Chahin, Brent Maxwell, Chad Seidel

<table>
<thead>
<tr>
<th>Group 1: Chahin, Laura</th>
<th>Group 2: Maxwell, Brent</th>
<th>Group 3: Seidel, Chad</th>
<th>Group 4: unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbone, Christopher</td>
<td>Chavez, Heilyn</td>
<td>Burdette, Stephen</td>
<td>Rivera, Michael</td>
</tr>
<tr>
<td>Carbone, Nicholas</td>
<td>Chavez, Pablo</td>
<td>DiStefano, Mary</td>
<td>Smith, Matthew</td>
</tr>
</tbody>
</table>

7:30 Mass
Head Servers: Mario Spencer, Lance Lanier, Stephen Balhoff, Megan Haas, Mallory Haas

<table>
<thead>
<tr>
<th>Group 1: Spencer, Mario</th>
<th>Group 2: Lanier, Lance</th>
<th>Group 3: Balhoff, Stephen</th>
<th>Group 4: Haas, Megan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spencer, Martin</td>
<td>Dawson, Ashton</td>
<td>Balhoff, Christopher</td>
<td>Haas, Mallory</td>
</tr>
<tr>
<td>Spencer, Nicholas</td>
<td>Dawson, Chanel</td>
<td>Ottega, Nicholas</td>
<td>unknown</td>
</tr>
<tr>
<td>Spencer, Tawny</td>
<td>Dawson, David</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spencer, Daniel</td>
<td>Dawson, Mary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9:00 Mass
Head Servers: Kyle Bacak, Ryan Bacak, Alec Herzog, Emma Herzog, Brandon Maxwell, Preston Phillips, Isaiah Smith, Chris Wuenscher

<table>
<thead>
<tr>
<th>Group 1: Bacak, Kyle</th>
<th>Group 2: Herzog, Alec</th>
<th>Group 3: Maxwell, Brandon</th>
<th>Group 4: Smith, Isaiah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacak, Ryan</td>
<td>Herzog, Emma</td>
<td>Phillips, Preston</td>
<td>Wuenscher, Chris</td>
</tr>
<tr>
<td>Bacak, Michael</td>
<td>Herzog, Eli</td>
<td>Maxwell, Benjamin</td>
<td>Smith, Alec</td>
</tr>
<tr>
<td>Vibar, Melanie</td>
<td>Brice, Matthew</td>
<td>Nagode, Jacob</td>
<td>Phillips, Grant</td>
</tr>
<tr>
<td>Vibar, Nicholas</td>
<td>Felman, Chris</td>
<td>Polzer, Rachel</td>
<td>Voiron, Malaina</td>
</tr>
</tbody>
</table>
10:45 Mass
Head Servers: Austin Crowley, Michael Floeck, Dusty Tobin

**Groups with unknown servers will borrow servers from other groups or other Masses randomly each month.**

**The leftover server at the 10:45 mass will rotate with the other servers in group 4. Whoever is leftover in a given month will help out at another Mass time.**