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A Distributed Approach to Group Model Building

by

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Chapter 1: Introduction

Today's society experiences a wide range of problems from crime and poverty to poor education and childhood obesity. These issues vary greatly based on location, severity, people involved, and societal influences. The stigma associated with these problems encourages mitigation of them, however the complexity and variation involved prevents universal solutions. Therefore, researchers and advocates must examine each occurrence individually and employ numerous techniques to fully understand a problem. Researchers are also constantly evolving techniques to capture the breadth and variation of these issues. One technique growing in popularity is group model building, which focuses on creating models of complex problems using groups of people. This technique has shown signs of success, but also presents opportunities for expansion in its application. The focus of this master's project is to develop a mobile application to formulate models for group model building.

1.1 Group Model Building

Group Model Building (GMB) is a participatory method used in understanding how complex systems work by bringing together a group of people to exchange their perceptions of a problem [7]. This group involves numerous stakeholders in the problem including law makers who can help push relevant social policy; advocacy groups who can develop programs; affected members by the problem, researchers, etc. One of GMB's overarching goals is to create a shared understanding in often-conflicting views [5]. These stakeholders come from different backgrounds and walks-of-life which can lead to different perceptions and intentions in what these people want to accomplish with the problem. Because of these conflicting views, group model building sessions aim to develop consensus by exploring questions such as: What is the problem we face? How did this problem originate? What might be the underlying causes? How might this problem be tackled [5]? While the focus of this project was model formulation, there are many other aspects involved with group model building including background research, recruiting participants, planning activities, and analysis of data.

1.2 Social System Design Lab

This project stemmed from a desire to pursue a cross-disciplinary project utilizing computer science and the social sciences. A partnership with the Social System Design Lab (SSDL), a research center of the George Warren Brown School of Social Work at Washington University in St. Louis was cultivated to complete this project. The overarching goal of the SSDL is to further the science, application and practice of system dynamics in human services. System dynamics is the overarching paradigm utilized by group model building aiming to understand how complex systems work. The SSDL is also an active participant in advancing the methodology involved in group model building and building models to represent these societal problems.

This project aimed to mitigate three key problems that the SSDL is currently enduring. The first of which is the existence of unsatisfactory modeling software. There are several available modeling software options, however, the user interfaces are complicated and designed specifically for modeling experts. This works well for the researchers at the SSDL with this knowledge, but the SSDL focuses on building models with participants unfamiliar with modeling. Additionally, existing software focuses on a single person building models, but the SSDL relies on the collaboration of many people to formulate a model. Therefore, the existing software solutions are not viable options.

Secondly, researchers at the SSDL want models to exist as a *boundary object* both inside and outside the group model building sessions. A boundary object is a shared visual representation of a complex problem that maintains a coherent identity of the dependencies and perceptions of participants across multiple social worlds [6, 10]. Boundary objects can also be modified by input from all participants [6, 10]. Collaboration among participants plays a significant role in a model acting as a boundary object, but currently this collaboration exists only during modeling sessions.

Outside of these sessions, models remain unaltered and cease to act as a boundary object. Communication is non-existent among participants and the ability to extend a model is difficult. The SSDL wants a solution that allows models to continue to function as boundary objects beyond modeling sessions by promoting outside model expansion by all participants with the ability to share progress with each other.

Lastly, there are limitations on the observation of how models are built. Exposure to a participant's comprehension of GMB topics and individual building patterns may be hidden through current observation methods. Additionally, current observation methods only provide qualitative data and differences in how recorders manually capture model building sessions can lead to difficult analysis. The SSDL not only want a new automated method to gather quantitative data on the building of models, but also want a method that captures the effectiveness of their current GMB techniques.

1.3 Project Overview

To address the problems presented in the previous section, a tablet application called iModelBuilder was created to help with the model formulation aspect of the group model building process. iModelBuilder addresses the problems the SSDL is experiencing by providing researchers a new method to develop models. This method can be modified and integrated into their existing process.

To mitigate the problems mentioned, three main goals were defined in the creation of iModelBuilder. The first was to provide a simple user interface that would allow users to focus more on learning and comprehending model building concepts as opposed to learning new technology. The second was to provide a mechanism to allow participants to share models and collaborate outside modeling sessions, which can strengthen the results from the modeling sessions and allow the model to continue to act as a boundary object. Lastly, there was a desire to provide an automated method to track how users build models to illustrate how this technology can be used to improve the GMB process. These three goals align with the three core pieces of the application architecture, which includes the user interface, a cloud based file management system, and metrics gathering.

Chapter 2: Application Architecture

2.1 User Interface

2.1.1 Problem

Using software to build models is not a new concept as options such as Ventana Systems Vensim [11] and iSee Systems Stella Modeler [4] are available. In this project, Vensim was used as the baseline software of comparison as it is freely available. Much of Vensim's core user interface consists of features used in later analysis stages of the modeling process. This overshadows and clutters the basic building blocks of a model an SSDL participant needs to comprehend. This complex user interface is a result of the Vensim modeling software being designed for experts in model building and analysis. However, the target audience of the SSDL is not modeling experts, but people who are domain experts in fields such as public health and education. The participants building the models are learning model building concepts for the first time, so having to learn this advanced software becomes overwhelming.

2.1.2 Model Basics

A basic model can be thought of as a directed graph, where the vertices of the graph are *variables* involved in the system. Figure 1 is a condensed example of a model looking at world population. The two variables considered in this model are Population and Deaths. The edges between the vertices represent a *relationship* between two variables. There are two relationships in the example, one from Population to Deaths and one from Deaths to Population. These edges demonstrate that Population has an effect on Deaths and Deaths in return have an effect on Population. These edges are also labeled with what is called a *polarity* which can take the value of '+' or '-'. A plus sign represents a positive relationship or both variables changing in the same direction while a minus sign represents a negative relationship or the variables changing in the opposite direction [1]. In the relationship from Population to Deaths, the positive polarity demonstrates that as population increases, deaths will increase since more people exist in the world. Likewise the negative relationship from Deaths to Population demonstrates that as the number of deaths increase, the population will decrease. This model also contains what is called a *feedback loop* since both Population and Deaths affect each other. This is commonly identified by a label that takes the form of a semi-circle with either an 'R' which stands for reinforcing or a 'B' which stands for balancing. In this example, the feedback loop is balancing because the polarities of the two relationships counteract each other.

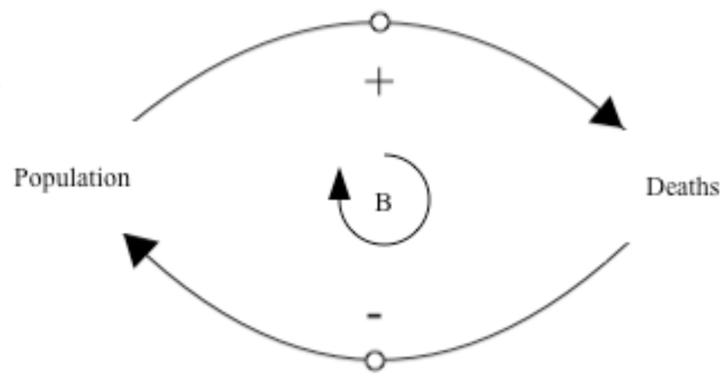

Figure 1: Condensed Model on World Population

2.1.3 User Interface Features

The user interface of iModelBuilder seen in Figure 2 is focused around a simplistic design compared to other modeling software (7 buttons vs. 54 buttons). The buttons are located across the top of screen and provide a variety of features: creating new models, opening and saving models through the cloud file management system, taking pictures of a model, and adding new model objects to the canvas. This provides the users only the essential building blocks needed to create a model while stripping out the advanced features of GMB. Also, with the increasing popularity of tablets, touch gestures are becoming commonly understood, which makes iModelBuilder easier for users than a corresponding desktop application.

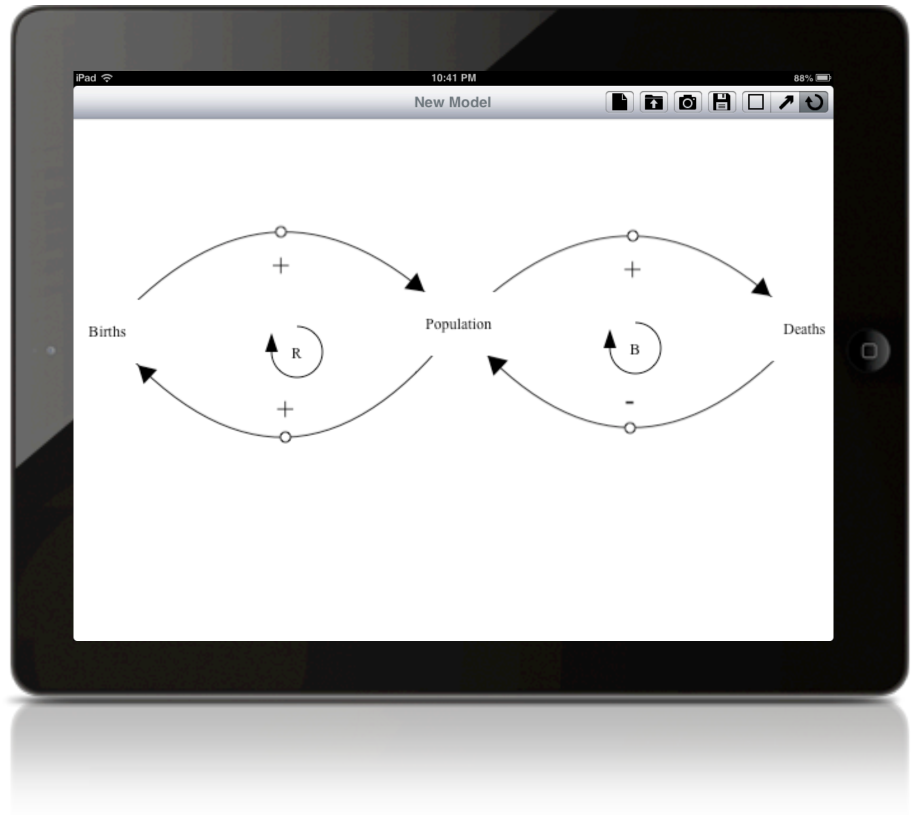

Figure 2: iModelBuilder User Interface

2.2 Cloud Based File Management

2.2.1 Problem

Collaboration is crucial to the success of group model building, but the SSDL is restricted to promoting this collaboration during the model building sessions. Typical group model building sessions last between a few hours to an entire day. At the end of a session, participants are given a paper handout of the created model. These handouts make it difficult for participants to expand models, collaborate with other participants and provide feedback to the researchers at the lab. Models become more individualistic thus limiting the value of extensions to models outside of modeling sessions. Because of these difficulties, models no longer maintain a shared representation among all participants and cease to act like boundary objects. Existing software such as Vensim does not provide a mechanism to share models between collaborators because it is designed for one model builder as opposed to a group of model builders. The SSDL has struggled to find a method that can cross the border of building models in sessions to building models in a distributed format.

2.2.2 Cloud Storage

To handle the collaboration features of iModelBuilder, a cloud based file storage service Dropbox [2] was utilized. Dropbox provides an API that allows easy incorporation of a users' Dropbox drive into the app. Dropbox also provides built in collaboration features such as shared folders. The SSDL use this feature by creating a shared folder for each of their projects such as childhood obesity and community violence. Then, the researchers can easily control who has access to different models. In addition, Dropbox provides folder update notifications letting researchers and participants know when changes have been made.

2.2.3 File Management Usage

Using this cloud based file management system allows the SSDL to continue using current modeling software as well as iModelBuilder to create models. Researchers who are already accustomed to using Vensim can start building a model in that tool. Researchers can then save the model to Dropbox and iModelBuilder can then be used to open the model. In order to create this compatibility between Vensim and iModelBuilder, the Vensim model files had to be reversed engineered. Visual aspects of the model in the model file were extracted and then recreated on iModelBuilder's user interface. For reverse compatibility, all models saved from iModelBuilder are also stored in this Vensim model format.

Participants of the group model building sessions on the other hand can avoid Vensim entirely and begin creating models through iModelBuilder. When the users open the app, they are presented with a blank canvas to either create a model from scratch or open an existing model such as a model created during a group model building session.

After a user completes work on a model, it can be saved through the app to Dropbox where the model will be stored for later use. Likewise, other collaborators or researchers can then view or add to what that participant has created. Researchers can also open this model in Vensim and perform more detailed or advanced analysis on the model.

By transforming the distribution of models to an electronic format, the models are no longer static outside of modeling sessions. Once the participants leave the group model building session, they can continue making additions to the model and share progress with other participants. Models now continue to act as a boundary object by giving all participants the capability to alter the model and create visibility into the extensions made by the participants. This further promotes the shared representation of the problem.

2.3 Metrics Gathering

2.3.1 Problem

The researchers at the SSDL employ many techniques to capture how users interact during group model building sessions, however this requires the presence of another researcher to document the discussions and products of the building session. This not only introduces the potential for missed information as the recorder has to keep pace with everything occurring at any given moment, but differences in skill of the observers will lead to variance in the recorded data. The qualitative nature of these observations makes it difficult to compare modeling sessions. Current observation methods also do not necessarily expose participants understanding of GMB topics unless questions or discussions are explicitly brought up in times of uncertainty. If participants do not fully understand these concepts, they may go about building models differently thus yielding less successful and meaningful models.

2.3.2 Tracking Information

Once the app is launched, all interactions with the user interface are tracked. This includes a wide range of interactions including, but not limited to, adding, deleting, or moving objects of the model, changing attributes of the objects such as a variable's name or the polarity of a relationship, the selection of different menu options and even the rotation of the device. When an event is triggered to gather metrics in iModelBuilder, a set of data is tracked. First a timestamp is provided so the researchers will have a better perspective on metrics such as the frequency of a certain event, total time of the modeling session, and time between interactions with the user interface. Along with timestamps, a generic message id and generic message description for each event allows researchers to divide the types of events into specific categories that allow for easier data analysis. Lastly, details about the event such as the new location of a moved variable allow researchers to drill down deeper into the finer details of the changes made by the users. From all of the metrics produced, every aspect of the resulting model is captured and the researchers can reconstruct a model based on this data.

2.3.3 Cloud Based Storage Usage

The metrics are stored externally in a cloud database called Parse. [8] Parse stores user modeling sessions which are defined as the events occurring between file saves by a user. Unlike standard databases, files can be uploaded to Parse allowing iModelBuilder to push a comma separated value (CSV) file containing the metrics of a user modeling session. The resulting model file is also stored in the database record so the researchers do not have to reconstruct the model from the data.

Additional information is also stored in the database to track progress of a model over time. This becomes increasingly useful for the researchers during analysis. First, a global ID is created to decipher between different users working from the same parent model, as will be the case for the SSDL. This allows the researchers to see how individual participants go about modifying the same model and the approaches each person takes. To track the chronological sequence of modifications of a model from an individual user, hashes are performed on the models at the beginning and the end of the model building sessions and stored in the database. When the researchers are ready to analyze data, they can run scripts written in Python that utilize a REST [9] web service to extract data from Parse. These scripts sort the data by global ID organizing the metrics and model files into sequential iterations. This provides the data in an organized format the researchers can use to examine modeling patterns of users.

2.3.4 Advantages Over Previous Methods

The metrics tracking offers some key advantages over existing methods the SSDL utilizes. iModelBuilder provides an automated method to gathering data. This produces quantitative data of user modeling sessions thus alleviating the discrepancies and manpower involved in manually recording data. Besides providing quantitative data, the metrics will demonstrate how the researchers at the SSDL can leverage this mobile technology with existing methods to improve the group model building process. The metrics are also one of the first methods that allow researchers to experiment with group model building in a distributed format where the participants and researchers are not collocated. Lastly, data gathered may expose how well participants grasp GMB concepts and help the researchers judge the effectiveness of existing techniques and improve their teaching methods if needed.

Chapter 3: Conclusions

3.1 Contributions

This project produced a new method to perform group model building. Both mobile technology and distributed model building are new techniques to GMB. This tablet application is the first step in opening the door to thinking about group model building in a different way. Researchers and participants are not restricted to working on models during a finite number of building sessions. Instead, participants can continue to expand and collaborate on models without being in close proximity with one another. Researchers can also remotely monitor progress with the metrics gathering and Dropbox integration. With the addition of this app to the SSDL, models have transitioned to acting as boundary objects beyond modeling sessions by continuing to maintain a coherent shared representation of the perceptions of the problem and dependencies among the various participants.

For the researchers, the biggest contribution of iModelBuilder is the ample amount of data it produces. This app and the data collected act as an assessment tool on many different levels. First, data gathered through current observation methods are qualitative, whereas iModelBuilder provides quantitative data that is more conducive for statistical analysis. Secondly, this data exposes the inner workings of computer-assisted approaches to group model building and how mobile technology specifically can be integrated to yield more productive and richer modeling sessions. The researchers at the SSDL have not relied on computer-assisted approaches heavily and there is minimal research on how to use this technology to advance GMB. Thirdly, this data also helps researchers evaluate their teaching methods as it offers a new perspective on how individual participants go about building models. The data exposes participant's comprehension of GMB topics and building patterns, providing insight into the effectiveness of the SSDL's methods and expose areas of improvement.

For the participants, they are provided with a tool containing only the essential features needed to create models. It becomes easier for them to apply what they have learned in the GMB sessions and continue to make progress on models through the application. The simplicity of iModelBuilder promotes comprehension of GMB topics and increases the speed at which participants build models. Participants also do not have to exert any additional effort to collaborate with other participants and researchers other than simply saving their models. Furthermore, participants become active members of model building outside of the sessions allowing them to share their ideas when it is convenient to their schedule.

Additionally, iModelBuilder has an influence that extends far beyond the researchers and participants of the SSDL. As a result of this project, the SSDL has been collaborating with the modeling software company iSee Systems who are building an iPad modeling application [3]. Multiple discussions on design, features, and implementations patterns have occurred. This has included providing the design, architecture and code of the metrics gathering of iModelBuilder to iSee Systems. The overall hope is to foster a long lasting relationship between the SSDL and iSee systems and promoting improvements to computer assisted GMB on future projects. The SSDL also works closely with other universities in sharing their newly created techniques and methods. One close collaborator is Deakin University, which recently received funding to create a tablet application for their research. With the SSDL as one of the innovators of applying mobile technology to group model building, the usage of iModelBuilder to enhance the group model building process at the SSDL can assist Deakin in the app they will be developing.

Lastly, the code created during this project has been incorporated into the open source community through Github and is freely available for usage and extensions. See Appendix A for the details.

Appendix A: Access to Project Artifacts

All of the artifacts to the project including the code base, documentation, write up, and presentation can be found publically off of the configuration management tool GitHub at https://github.com/mdburch/GroupModeling

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