MUD: EXPLORING TRADEOFFS IN URBAN DESIGN

MARK D. GROSS*, LAURA PARKER*, AND AME M. ELLIOTT†

*Sundance Laboratory for Computing in Design and Planning
College of Architecture and Planning
University of Colorado, Boulder, CO, USA 80309-0314

†College of Environmental Design
University of California, Berkeley CA, USA 94720
{mdg@cs, parker@ucsu} .colorado.edu, aelliott@ced.berkeley.edu

Abstract

The design of cities and neighborhoods involves multiple stakeholders with various agendas, each comprising multiple criteria. Any design proposal will rank differently against each stakeholder's agenda, and effective participatory design requires that stakeholder interests are mutually understood and negotiated. We describe a program to promote this understanding and negotiation among stakeholders, called MUD, that enables each stakeholder to articulate their criteria for judging designs, to make design proposals, and to score designs against the criteria. By enabling stakeholders with different values and different areas of expertise to exchange design proposals and agendas we hope to foster understanding and stimulate negotiation.

1. Introduction

Efforts to design successful built environments must be negotiated among stakeholders who hold diverse and often conflicting values about the built environment (Branch, 1985) Because of this multiplicity a platform for comparing design solutions is required. We are developing MUD, a decision support tool for teaching and learning about multiple objective design problems. Our MUD program enables stakeholders to score designs against various agendas, providing a flexible, quantitative, and visual means to compare designs in order to facilitate further negotiation.

Designing for a community requires balancing diverse viewpoints and values. Neighborhood planning meetings, for example, include not only architecture and planning professionals but also individuals and groups advocating their own agendas. Any design product will perforce make tradeoffs among the various values. Therefore the design process should offer opportunities for participants to explore and understand these tradeoffs. We describe a computer based tool called MUD (Multi-user Urban Design) that supports this exploration and attempts to promote a better understanding of design tradeoffs by urban design stakeholders. We plan to employ the MUD program as

a learning tool in planning and design courses at the University of Colorado at Boulder to teach students about tradeoffs among stakeholders in multi-criteria design.

We define a 'stakeholder' as any person, group, or entity that is affected by changes made to the built environment or has some vested interest in those changes. For example, an individual resident, a business group, a city engineering department, and the mayor may all be stakeholders in an urban or neighborhood design. Each stakeholder holds values about the built environment, by which they judge proposed designs. We use 'agenda' to mean the expression of these values as a set of specific criteria and weights that allows a stakeholder to assign a numerical score to any proposed design. We define a criterion as a quality of the physical environment that can be measured as present or absent.

Using the MUD program entails three conceptual phases. In agenda-setting a stakeholder expresses a set of design objectives using a formal language of elements, relations, and preferences. In design exploration, a stakeholder uses a simple two-dimensional CAD program to lay out a design alternative. In evaluation, a stakeholder examines the performance of the design alternative with respect to various agendas, including his or her own. MUD is highly interactive so the three phases are not rigidly sequenced. The designs and agendas of other stakeholders are available and a stakeholder can test a design against the agendas of other stakeholders or test designs made by other stakeholders against his or her own agenda.

Multiple criteria is the hallmark of any design problem, even those few design problems that involve only a single stakeholder. And, in real-world design multiple stakeholders are the norm, not the exception. Therefore we believe that MUD offers a model for teaching and learning about multi-criteria, multi-stakeholder design in any domain, and is not limited to urban or neighborhood design. However, urban design appears to be a particularly easy domain in which to understand the concept of diverse stakeholders who each have various agendas.

A great deal of work has been done on solving multi-criteria design problems, based on weighted optimization methods and pareto optimality (Gero, 1985) . In such systems, a designer enters all the various constraints, objectives, and preferences, and using numerical methods the computer program produces a solution. Optimization is useful when the designer(s) can make accurate and precise assessments of the constraints, objectives, and preferences. However, this is often not the case in design problems. Rather, as the late design methodologist Horst Rittel observed, "understanding the problem is identical with solving it." (Rittel, 1972) In other words: Understanding tradeoffs among objectives in a design problem and reaching agreement among stakeholders about the relative merits of objectives precisely enough to express them as a set of weights is a most difficult part of design, which typically requires a great deal of exploration. We therefore emphasize that MUD is not a system for design problem solving; *it is a system for exploring design tradeoffs.*

The language-based approach we follow in MUD, providing a vocabulary for developing design evaluations, complements Kalay's P3 model (Kalay, 1997) (process, product, and performance), which deals with informing the public and soliciting feedback, aiming

to construct a shared understanding by helping participants come up with a consistent design vocabulary.

Rittel proposed to support the exploration of tradeoffs in community planning processes through what he called "issue based information systems" (Rittel & Kunz, 1970) , instances of which have been built by McCall, Conklin, and others (Conklin & Begeman, 1988; McCall, 1989) . Such systems support deliberation about a design by providing a structure for representing issues, answers, and the pros and cons of each alternative and sub-alternative. This type of system is invaluable for keeping track of the design argument among participants, but alone an issue-based system is unhappily divorced from the act of design. Systems that integrate argumentation in a design environment have been built by McCall and his colleagues, including the Janus-Crack design environment for kitchens, and the PHIDIAS-II HyperCAD system for the design of space based habitation (Fischer, McCall, & Morch, 1989; McCall, Bennett, & Johnson, 1994) . However, neither of these systems emphasized evaluation in the context of design, nor did they allow end-user programming of evaluative criteria. In Janus-Crack, for example, evaluation was limited to hard coded critics that detected specific conditions in the design. On the other hand, evaluation of design performance has been explored in a number of computer aided design systems (Kalay, 1992; Rutherford, 1993) . Some of these systems support multi-criteria design; few, however also support multiple stakeholders. Combining these approaches, our MUD program entails both evaluation of designs and the design of evaluations by multiple stakeholders.

The remainder of the paper is structured as follows: In Section 2 we outline an example of an urban design project in Boulder, Colorado, USA. Analysis of the project points out some features needed in a computer system to support urban design. In section 3 we describe the nature of the relationships between stakeholders, their agendas and the criteria that comprise those agendas. We present the elements of the MUD program, including the MUD-L language for expressing urban design criteria. Section 4 describes the MUD interface: how designers specify agendas and lay out site plans. They can then test their site plans against their agendas, and against the agendas of other stakeholders. Section 5 outlines the implementation of the MUD program. Section 6 concludes with a discussion and some directions for future work.

2. Real Urban Design: Boulder Future Employment Rezoning Project

We examined a real urban design project, the City of Boulder Future Employment Project (BFER), that was conducted in January and February, 1997. We wanted to observe the design process and methods employed by urban planners to ascertain the consistency of our approach with current planning practices. BFER's goal was to enact a comprehensive rezoning of the city to balance the number of projected jobs with available housing. As subsidiary goals, BFER also aimed to reduce traffic congestion and to retain the small scale character of the city.

BFER was broken down into eleven community zoning districts. Each district held an open house meeting for community members to discuss and negotiate proposed changes.

We focused on district #5, the Boulder Junction area. The program for the Boulder Junction area called for changes to four land use zones: the Main Street/Mixed-use zone, the Industrial/community business zone, the Mixed density residential zone and the Mixed-use zone. In each district a new zoning requirement was set for 17 different 'use definitions' that spell out physical requirements, or criteria. Use definitions used in the Boulder Junction area were: minimum lot area, maximum building height and minimum distance from building to road. These measurable design qualities correspond to the relationships we provide in MUD (see section 4).

From the analysis of the Boulder Future Employment Rezoning project, we found that four key features are needed in a computer system to support participatory urban design. These features are as follows:

2.1. PRELIMINARY DESIGNS: A STARTING POINT FOR NEGOTIATION.

In the BFER project, city planners began negotiation by presenting a preliminary design to the public. Presentation of a design for consideration by other stakeholders is the primary means of communication in planning and must be incorporated into a system that supports design with multiple stakeholders. The BFER project held public information displays around the community, distributed information packets and maintained a World Wide Web site with a description of preliminary design phases. Open house workshops were held in each of the proposed areas of change to provide a forum for presenting and discussing designs. The BFER web site contained descriptions and diagrams of proposed changes in each district.

Presentation of preliminary design can also be construed as the schematic design phase. This phase is necessary for negotiation before more detailed plans are proposed. The schematic design presentation must remain accessible to stakeholders so that changes can be easily made. For example, in the BFER project, maps were displayed showing alternative zoning solutions to the same problem, thus allowing for manipulation of the design on a conceptual level using schematic representations of possible solutions.

2.2. AGENDA SETTING IS PART OF THE URBAN DESIGN PROCESS.

Stakeholders have agendas, whether they express them or not. By formally stating one's agenda, stakeholders articulate their needs and the criteria they wish to see met. Agenda setting was conducted in BFER through various means. Rezoning the city to balance jobs and housing was the agenda of the City Council. The agenda of The Downtown Alliance (a group of citizen boards including the Downtown Management Commission, Downtown Design Advisory Board, Landmarks Preservation Advisory Board, Planning Board) was to develop the downtown area in a manner that maintains the livability and "feel" of downtown, and to protect the downtown's historic character. Other nonprofit downtown stakeholder organizations participated in BFER such as Downtown Boulder Inc., Historic Boulder, and representatives from several neighborhood groups. The various stakeholders worked together to implement changes that incorporated successful trade-offs between the interests of each group. Trade-offs in a project like this can be expressed in terms of the agendas articulated by stakeholder groups.

2.3. DELIBERATION IS A MEANS TO DESIGN EXPLORATION

A computer system for supporting multi-stakeholder urban design must be able to accommodate the discourse and deliberation that occurs in design exploration. In BFER, the design exploration phase was conducted through open house sessions with the community, presentation of preliminary summaries of proposed zoning changes, development of 'use and bulk' charts, and overviews of current zoning in the city of Boulder. The open house sessions were used to explore the tradeoffs between the objectives of various user groups and City Council. Deliberation occurred during the open house sessions through analysis of the maps of proposed changes and 'use charts' and 'bulk charts'. Use charts specify which uses are permitted, prohibited, or conditional, or require use reviews for each of the City's zoning districts . Bulk charts include building height limitations, lot coverage requirements, building setbacks or yard requirements, usable open space requirements, minimum lot sizes, and density requirements. Preliminary designs developed by professional planners were presented to the public by City Council and comment and feedback from the public was solicited. The feedback was used in considering the next phase of changes. Summaries of proposed changes were placed as information displays in the Public Library and in the Courthouse.

2.4. INCREMENTAL SPECIFICATION OF DESIGN CRITERIA

Design can be seen as a process of incremental refinement. In BFER the initial exploratory design phases led to attempts to specify the initial project objectives in physical terms. The overall project objective was to balance housing and jobs. After several iterations of preliminary design, the objective was defined more explicitly. The objective became for City Council and other participating stakeholders to rezone commercial areas into mixed use and residential areas. Again, the objective was defined in more specific terms: Rezone commercial areas in the Boulder Junction area to attain a ratio of 3:1 residential to commercial. Thus the larger higher-level objective of balancing jobs and housing was ultimately redefined in terms of specific land use practices.

3. Stakeholders have agendas made of weighted criteria

In urban design, as in many complex design problems, (almost) everything is connected to everything else in a complex chain of causality. Design thus entails a game of attempting to solve one problem while not disturbing previously reached solutions, and trying to understand the effects any design decision will have on other decisions. Because there are many different stakeholders with diverse agendas, it is difficult to keep in mind the decisions that are important to others. Methods for partitioning decisions into closely related clusters address this problem analytically (Alexander, 1966; Owen, 1970) . Here we explore a simpler approach of providing stakeholders with a visual reference to the agendas of other stakeholders. MUD provides this visual reference with gauges that we call 'urbometers' that graphically display the performance of a design with respect to a given stakeholder's agenda.

3.1. STAKEHOLDERS HAVE AGENDAS

All stakeholders in an urban design project have various objectives they wish a design to meet. We call the set of a stakeholder's objectives an 'agenda'. An agenda can consist of a single objective: an advocacy group works to keep a potentially polluting factory from being built in their community. The importance of a single objective is paramount. But an agenda can also consist of many sub-objectives with varying degrees of importance. For example, a city council wishes to control growth, promote business, and attract tourism. The various issues may have different levels of importance.

Urban design projects are often cast under an overarching rubric. For example, the Boulder Future Employment Project focused on balancing jobs and housing. However, there are many means to accomplishing the objective. Stakeholders do not necessarily focus on this top level goal; rather they are concerned about the possible effects of proposed changes with respect to their own agendas. A group of business owners may not have a vested interest in Future Employment, yet they have a strong interest in the quality and character of the downtown area. Negotiation between stakeholders with differing agendas (which may also contain divergent criteria) must occur in a framework for comparison that can provide an analysis of how a specific proposal affects one's own and other stakeholders' agendas.

The agendas of stakeholders often deal with political and economic objectives rather than directly with physical ones, and it is a challenge to translate these 'higher level' objectives into specific criteria and decisions about physical form. For example, business owners may wish to increase the number of customers; this may be realized concretely by providing additional on-street parking within 100 meters of the business. Neighborhood residents may wish to increase the safety of a street; this may be realized concretely by reducing the width of the street to slow traffic, or by installing a stop sign at every corner.

We concentrate here on the physical decisions that must ultimately be made to realize a design, and leave the translation from 'higher level' goals to their 'lower level' physical implementations as a problem for the user. That is, we require MUD users to state their criteria and agendas in terms of the urban design elements and spatial relationships that make up a plan, rather than higher level objectives that ultimately drive their decision making. We leave for a future project translation from political and economic goals to the physical agendas in MUD (but see Koile, this volume, on the relation between physical form and non-physical design characteristics (Koile, 1997)).

3.2. AGENDAS ARE MADE UP OF CRITERIA

An agenda comprises a set of criteria. Each criterion expresses a single goal, or desired property of the design. Here are some criteria:

- "I want a park"
- "I want a two-to-one ratio of office space to commercial space."
- "I want a park within a distance of 100m of every block of housing."

- "I want two parking spaces for every 100 m^2 of housing."
- " I want no more than 1000 m^2 of commercial space."

From these examples it is clear that a criterion involves one or more design elements, ('park', 'housing', 'commercial space'), properties of these elements ('area of park', 'number of parking spaces'), and constraints and relationships on these properties ('no more than 100 m^2 of', 'within a distance of', 'a ratio of'). We provide a limited palette of design elements, which correspond to the basic elements typically found in urban design site plans. For example, our palette includes park, commercial, street, parking, and housing elements.

Some properties involve a single element ('the length of this park'). Other properties are collective over all instances of an element class ('area of housing'). We concentrate on the properties of area (square meters of housing, commercial, park, etc.), number-of (there must at least two commercial areas), and linear dimensions. Some relationships are unary; they involve only a single design element or class of design elements. For example, 'I want a park', 'no more than 1000 m^2 of commercial space' involve only a single element or element class. Other relationships are binary; they involve two elements or classes: 'two parking spaces per 100 m^2 of housing', 'distance from housing to park'.

3.3. EXPRESSING CRITERIA IN THE MUD-L LANGUAGE

We have constructed a language for discourse about urban design in which stakeholders can express their values. We call the language MUD-L for Multi-User Urban Design Language (pronounced "muddle"). MUD-L aims to capture and convey the sorts of criteria described above in a fashion that both a human and a computer can read and interpret. MUD-L has a simple Lisp syntax to express elements and relations. For example, the criterion "I want a park" is expressed in MUD-L as (Exists Park). The criterion "I want a ratio of two-to-one office space to commercial space" is expressed as (Ratio Office Commercial 2/1). MUD-L statements are Lisp predicates, so evaluating a design with respect to criteria expressed in MUD-L is as simple as calling Lisp's 'eval' function on each criterion.

The stakeholder must determine the importance of each criterion, that is, its weight in relation to other criteria in the agenda. For example, for the criterion (Exists Park), the stakeholder must decide "How important is it that a park exists in this area?" Thus, the stakeholder assigns each criterion a numerical weight to express its relative importance. The user specifies a numerical weighting value for each criterion on a scale 1-10 (10 = very important); MUD normalizes the weights so that the total of the normalized weights equals 1.0. An agenda thus comprises a set of criteria and their associated weights. For example:

```
8 (exists park)                          ; I want a park, weight 8 (very important!)
5 (min-area housing 10000)               ; Area of housing ≥ 10,000 m2, weight 5
3 (max-distance housing park 100)  ; distance housing to park≤100m, weight 3
```

4. The MUD Interface

MUD runs as a single-user system on a personal computer (Macintosh), though several users can run MUD on separate workstations and collaborate by sharing designs and agendas stored on a central server. Using MUD entails three distinct activities, which we describe below.

4.1. AGENDA SETTING

Each stakeholder constructs an agenda using a simple dialog-menu interface to construct statements in MUD-L, the simple urban design language we have constructed for MUD. The MUD-L language comprises nouns, predicates, and quantifiers. Nouns describe the elements of an urban design, for example units of housing, commercial building, parks, and streets. Predicates describe characteristics of design elements and relations among them, for example maximum-number-of, area-ratio, maximum-distance-between. Quantifiers allow specific numeric values to be added to the criteria: numbers of units, areas, and distances.

Figure 1 shows the interface dialog for constructing an agenda. The dialog contains a table of relationships (left side, first column), a table of basic urban design elements (left side, second column), and a type-in box for specifying numeric values. A stakeholder constructs each criterion by selecting a relationship, one or more urban design elements, and numeric quantifier values. For example, from the relationships column, the stakeholder chooses ‘exists’; then from the elements column, ‘Park’; and finally enters the weight ‘8’ to construct the weighted criterion ((Exists Park) 8). The stakeholder also selects a weight for each criterion, and adds the weighted criterion to the current agenda. The list of criteria in the agenda appear in the table at the right. A name for the agenda can be entered in a typein box at the bottom.

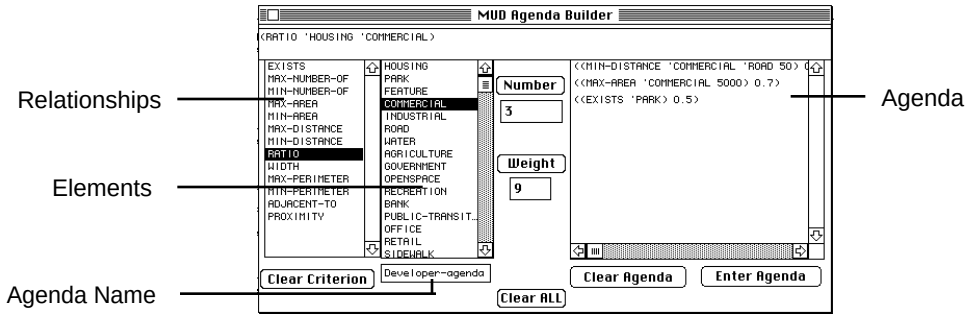

Figure 1. Stakeholders select elements, relationships, and weights to construct the criteria in an agenda.

When the stakeholder finishes adding criteria to construct the agenda, the system produces an 'urbometer', a gauge that displays the score of design alternatives according to the newly constructed agenda (figure 2). The black horizontal bar indicates the current score—the extent to which the current design satisfies the agenda. The criteria and their (un-normalized) weights appear below (scale 1-10) . The bullet (black circle) to the right of a criterion indicates that the criterion is satisfied in the current design state.

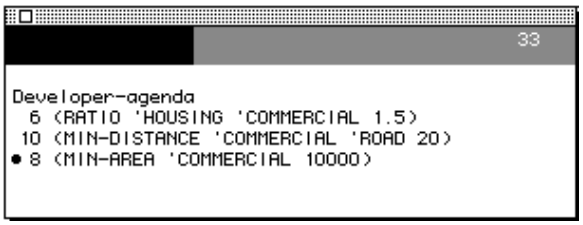

Figure 2. Urbometer displays score of design with respect to an agenda.

4.2. LAYING OUT SITE PLANS

Traditionally urban designers create plans by laying out a site plan and iteratively producing preliminary designs and evaluating them with respect to design requirements. MUD supports this process with a simple palette-based drawing program. Figure 3 shows the palette and work area.

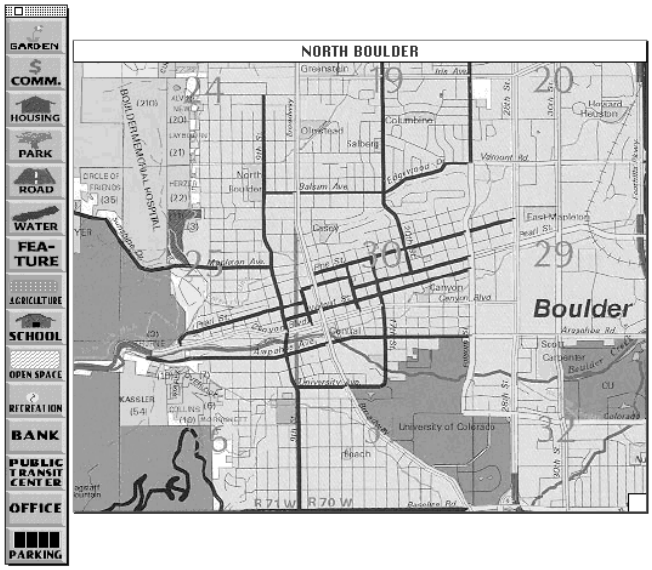

Figure 3. MUD tool palettes and work area with an underlay of the site.

The work area displays a site plan underlay, typically a map or an aerial photograph scanned and imported into MUD. On top of this underlay the stakeholder-designer selects elements (park, housing, commercial blocks) from the tool palettes at the left and assigns them locations and sizes. The elements appear as color coded rectangles, lines, and graphic symbols similar to traditional urban design representations.

4.3. EVALUATION: WATCH THE URBOMETERS

As a stakeholder lays out urban design elements in the work area, MUD scores the design performance against the currently active agenda or agendas. Scoring is incremental, updated with every new element or editing operation the stakeholder makes to the design. The agenda scores are represented visually on a collection of urbometers, which indicate graphically the performance of the design with respect to the criteria in that agenda.

Figures 4 and 5 show alternative designs and the scores of these alternatives according to three different agendas. The three agenda urbometers are presented together in a single window to make it easier to compare them. The three agendas each have three criteria. They differ both in the criteria they require and their weights. As elements are added to the design the urbometers fluctuate, gauging to what extent each agenda has been satisfied.

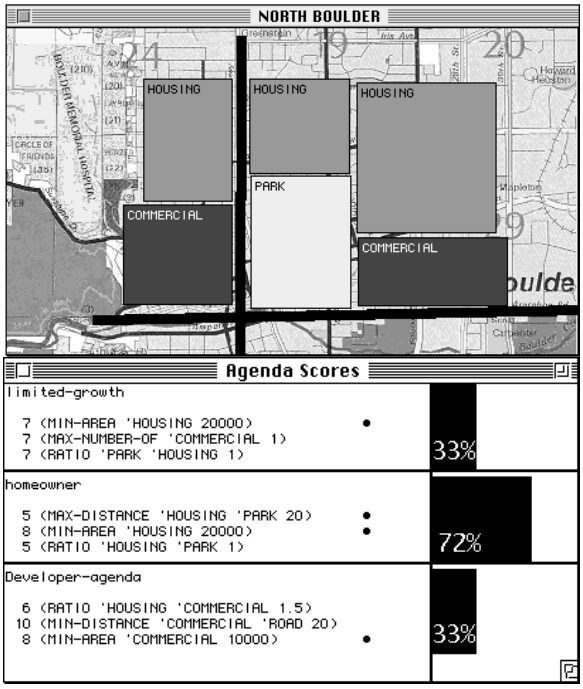

Figure 4. Design alternative #1 and scores according to three agendas. A black dot (bullet) indicates a satisfied criterion; the black histogram bar indicates the design's score according to the agenda.

Figure 4 shows a design with two commercial areas (dark gray) located along the east-west road (thick black line) and a park at the center of town, with housing zones to the north. The first agenda gives a low score to the design, because only one of its criteria is satisfied (minimum area of housing 20,000). The weights on the three criteria are equal, so in this case the score is 33%, or 1/3 of the criteria met. The second agenda gives a better score to the design, because the minimum area of housing is met as is the maximum distance between housing and park. Only the 1:1 ratio of housing to park is not met. Finally, the third agenda scores the design poorly as only the minimum commercial area is met.

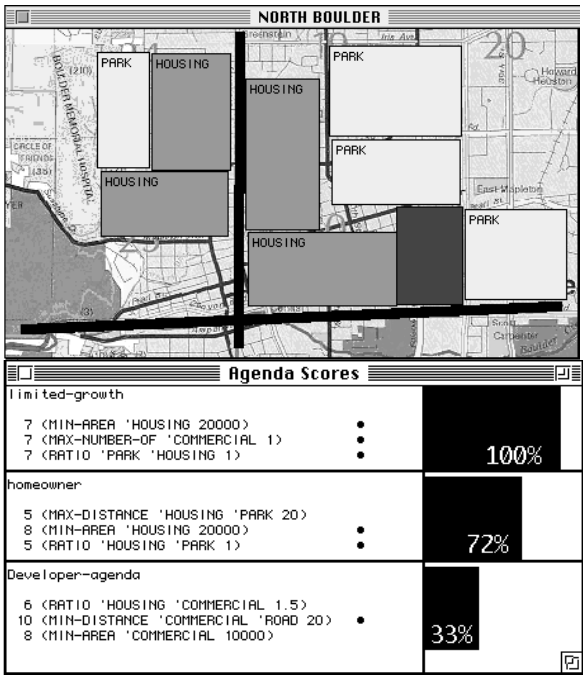

Figure 5. Design alternative #2 scores differently according to the same agendas as above.

Figure 5 shows a second design alternative, in which housing is clustered around the north-south road and parks are arranged at the outlying edges. A single commercial zone is located toward the east end of the east-west road. The scores according to the same agendas as in figure 4 are shown below. The first agenda is entirely satisfied (100%): the design meets its minimum area of housing, its limit of one commercial area, and its ratio of 1:1 park to housing. The second agenda is partly satisfied: the maximum distance criterion from housing to park is not met (the housing zone at the crossroads is too far from the nearest park). The third agenda has only one satisfied criterion: the maximum distance from the commercial zone to the road. The score is slightly greater than 33% because that criterion is weighted more heavily than the other two.

5. Implementation

5.1. DATA STRUCTURES FOR URBAN DESIGN ELEMENTS

MUD was begun as an extension of a 2-D draw program, written in Macintosh Common LISP as a student project for a programming class. A main display list keeps track of each element added to the design. Each element datum includes the element type, a particular name (if the designer chooses to specify a name), and its location coordinates (in pixels) needed to draw it on the screen. For example:

```
(housing pruitt-igoe ((100 100) (200 150))
```

describes a block of housing called "pruitt-igoe" that is a rectangle located at coordinates top left = (100,100) to bottom right = (200, 150).

5.2. DATA STRUCTURES FOR CRITERIA AND AGENDAS

The data structure for each agenda consists simply of an agenda name and a list of weighted criteria in which the weights have been normalized to sum to 1.0. For example, the agenda described above would appear normalized as follows:

```
(agenda park-housing
 ((exists park) .5)                          ; I want a park, weight 8 (very important!)
 ((min-area housing 10000) .3125)            ; area of housing ≥10,000 m2, weight 5
 ((max-distance housing park 100) .1875))    ; distance housing to park ≤ 100m, weight 3
```

5.3. EVALUATION OF DESIGNS

Evaluation of a design with respect to an agenda is straightforward. Each criterion is a predicate, which can be evaluated on the current design state. For example, (exists park) is either true or false; either there is or there isn't a park in the current design. If there is, the criterion's weight is added to the agenda score. Each criterion is thus evaluated and the weights added to arrive at the total score for the design with respect to the agenda. The maximum score is one; the minimum, zero. For example, if (in the current design) there is a park, and there is more than 10,000 m^2 of housing, but the maximum distance from housing to park is greater than 100m, then the design will receive a score of (.5 + .3125 + 0) = .8125.

6. Discussion and Further Work

We have described the current version of the MUD program. It provides a visual environment for proposing urban designs and evaluating them according to multiple agendas, each consisting of multiple criteria. The MUD-L language provides a means for stakeholders to express their objectives in terms of specific physical design characteristics. The MUD program provides an environment for collaborative work in urban design that aims at consistent recognition of all stakeholder agendas during design. It provides stakeholders a means to compare and evaluate various designs according to

different values. It allows designer-stakeholders to quickly see the effects of a design on the agendas of other stakeholders. Expressing urban design goals in a language that can be understood by designers and also quantified begins to provide a framework for argument, evaluation, and decision making.

6.1. MUD IN THE CLASSROOM AND STUDIO

In interviews in a third year (architecture) design class, students found it very difficult to articulate specific spatial relationships that enhance or detract from neighborhood quality. Instead, their remarks were directed at experiential qualities (safety, noise level, privacy) and not at specific, measurable, qualities of the built environment. Yet specifying physical characteristics is the essential job of designers. When pushed, students resorted to the ineffable: 'when I draw it just comes to me', 'I can't describe it but I know it when I see it'. We began to realize that explicit translation from experiential qualities to physical decision making is an important but neglected skill in our curriculum, and one that our MUD program might help students to develop.

Also, we have found that students of architecture and planning find it nearly impossible to deal with multiple stakeholder design problems. Typically a student designer will either give up and ignore all but one of the stakeholders' objectives, or try to synthesize *a-priori* a compromise agenda, in order to proceed with the designing. Compromise is inevitable, but students tend to adopt a compromise agenda before they have fully understood the tradeoffs entailed in diverse stakeholder objectives.

It seems difficult for novice designers to apprehend the fact that a given design may at once be good from the perspective of one group of users and bad with respect to another. Therefore, we plan to employ MUD as a teaching tool in a course on design methods in hope of making students aware of the complexities of multiple agenda, multi-criteria design and the attendant need for negotiation.

In this classroom-studio setting we will provide a design scenario and assign students different roles. For example, we will ask one student to represent the developer who wishes to build commercial buildings; another to represent young parents with children, and so on. Each student must construct an agenda that corresponds to their assigned role. We will ask them to make a design that maximizes performance with respect to their agenda. They will post their agendas and designs in a shared electronic bulletin board on the class web page. Then we will ask them to use their own agenda to score designs made by other students and to score their own design against the agendas made by others. We hope by these means to begin a classroom dialogue among designer stakeholders that promotes collaboration and negotiation, using urban design plans and agendas as concrete learning tools: 'objects to think with'.

6.2. FROM PHYSICAL FORM TO EXPERIENTIAL CRITERIA

We've insisted in this version of MUD that stakeholders express their design agendas in terms of specific physical criteria by which a design can be measured. We believe (as we mentioned above) that this is a valuable exercise for stakeholders: to translate experiential criteria such as "I want a place for my children to play" into physical and

directly measurable statements like "I want a park within 100 meters of my house". However, we would also like to provide computer support for making these translations from experiential to physical decisions. This could make it easier for stakeholders who are not skilled designers to express their values in terms of 'higher level' goals and then use the program to evaluate designs. This would entail the construction of a higher level language on top of MUD-L, in which experiential qualities such as safety, quiet, good for children could be described in terms of physical criteria such as street width, presence of traffic lights, and distance from house to school.

Providing a higher level language of experiential qualities opens the door to more innovative problem solving. When design agendas are stated in terms of physical criteria, it remains only to evaluate and compare designs. Our MUD program provides a simple and visual means to do this. But there may be several ways that the environmental quality of safety (for example) can be provided; a skilled designer can choose among these alternative methods to provide desired outcomes. For example, one stakeholder may want on-street parking and therefore designs a wide street; another wants safety and therefore designs a narrow street (to slow down traffic). At the lower level of these physical decisions the difference in objectives seems irreconcilable. But, reasoning at the higher level of experiential goals, a stop light will resolve the apparent conflict. Thus enabling stakeholders to express values in terms of experiential qualities may allow more innovative design solutions.

6.3. THE REASONS BEHIND AGENDAS

We mentioned earlier the decision support methods of Rittel, McCall, and others who employ an 'issue based information system' to support argumentation, negotiation, and deliberation among various parties to a design decision. The issue base constitutes a repository of facts and opinions about a design and its desired outcome, and can be valuable both during a design process to support group and community decision-making, as well as afterward, to record design histories and rationale. However, these decision recording tools omit a crucial part of the process: construction and evaluation. Conversely, our MUD program, which provides exactly this type of support, fails at archiving the argument, negotiation, and deliberation that naturally surrounds construction and evaluation by a group of differing stakeholders. It makes sense to put these two approaches together: Consequently, our ideal architecture for multi-user, multi-criteria design decision making would employ both kinds of support tool a construction kit for making designs, the means to set agendas for evaluating designs and to evaluate designs according to agendas, and the integrated means to record these events for later perusal in a structured database. An issue based information system such as McCall's PHIDIAS-II program would seem suited to these activities, and we plan to explore using this or similar technology to support design negotiation in future versions of MUD.

Acknowledgments

The CAD Research Group at the College of Environmental Design, UC Berkeley offered support and valuable discussions to Ame Elliott. Laura Parker received support for this project from the University of Colorado Undergraduate Opportunities Program (UROP).

References

Alexander, C. (1966). *Notes on the Synthesis of Form*. Cambridge: Harvard University Press.

Branch, M. C. (1985). *Comprehensive City Planning: Introduction and Explanation*. Washington DC.: Planners Press.

Conklin, J., & Begeman, M. (1988). gIBIS: a hypertext tool for exploratory policy discussion. In *Conference on Computer-Supported Cooperative Work*, (pp. 140-152). Association for Computing Machinery.

Fischer, G., McCall, R., & Morch, A. (1989). JANUS - Integrating Hypertext with a Knowledge-based Design Environment. In *Hypertext '89 Proceedings* (pp. 105-117).

Gero, J. S. (Ed.). (1985). *Optimization in Computer Aided Design*. Amsterdam: North Holland.

Kalay, Y. (1997). P3: An Integrated Environment to Support Design Collaboration (CAD Research Group Working Paper). Center for Environmental Design Research, University of California, Berkeley.

Kalay, Y. E. (Ed.). (1992). *Evaluating and Predicting Design Performance*. New York: Wiley.

Koile, K. (1997). Design Conversations With Your Computer. In R. Junge (Eds.), *CAAD Futures '97* (this volume).

McCall, R. (1989). MIKROPLIS: a hypertext system for design. Des. Studies, 10(4), 228-238.

McCall, R. J., Bennett, P., & Johnson, E. (1994). An Overview of the PHIDIAS II HyperCAD System. In A. Harfmann & M. Fraser (Ed.), *ACADIA (Association for Computer Aided Design in Architecture)*, (pp. 63-74). St. Louis, MO.

Owen, C. L. (1970). DCMPOS: An Algorithm for the Decomposition of Directed Graphs. In G. L. Moore (Eds.), *Emerging Methods in Environmental Design* (pp. 133-146). Cambridge, MA: MIT Press.

Rittel, H. G. (1972). On the Planning Crisis: Systems Analysis of the 'First and Second Generations'. Bedriftsøkonomen(8), 390-396.

Rittel, W., & Kunz, W. (1970). Issues as elements of information systems Working Paper 131. Center for Planning and Development Research, University of California, Berkeley.

Rutherford, J. H. (1993). KNODES: Knowledge Based Design Decision Support. In U. Flemming & S. van Wyk (Eds.), *Computer Aided Architectural Design Futures '93* (pp. 357-374). Amsterdam: North Holland.