DATABASE SYNCHRONIZATION TECHNOLOGY FOR MULTI-PROJECT SCHEDULE COORDINATION

by

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ABSTRACT

This paper describes a computing environment, called WorkMovePlan, that supports the exchange of data pertaining to resources shared between multiple production units and between multiple projects. It presents issues related to the generation and management of this data exchange and the development of a distributed, multi-project scheduling system that is deployed in industry practice.

KEYWORDS: Planning; Scheduling; Distributed Scheduling; Multi-project Scheduling; Database; Synchronization; WorkMovePlan.

1. INTRODUCTION

In a complex and dynamic construction project, no single participant can work in isolation for long. In addition, many participate in several projects at the same time. Work of every participant is interwoven with work of others. This is especially true for those responsible for production—designers, construction personnel, and other specialists who as individuals or as a team make up a production unit (PU)—as their deliverables are prerequisites to the work of others.

Production activities of PUs are interlinked because of physical dependencies and resource dependencies (here, resources are information, material, personnel, equipment, and space). Whereas physical dependencies clearly determine activity sequencing (e.g., in-wall electrical and plumbing systems have to be placed before wall panels are installed), resource dependencies do not: multiple activity-sequencing alternatives might exist.

From the perspective of the PU performing these activities, one alternative might not have a clear advantage over another, but from the perspective of others, or from the perspective of the project as a whole, it may be superior, for instance, if it "releases" more work or more resources. Conversely, what one PU identifies as a superior alternative may be inferior on a broader systems basis.

The WorkMovePlan system described in this paper provides database and graphical support for PUs to explore and rank alternatives, but it keeps people in the loop; WorkMovePlan does not automate this process. Job-shop scheduling, multi-objective decision-making, and heuristic optimization are needed to gauge and trade off what is best for individual PUs vs. the system, but discussing these is beyond the scope of this paper.

2. RESOURCE- vs. PROJECT-CENTRIC DATA

Planners can assess the value of and compare alternatives only if and when activity descriptions are detailed enough and especially when shared resource assignments are made sufficiently explicit (exactly how detailed and

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specific they have to be depends on the situation). However, a single planner probably does not have the knowledge to provide all that is needed. PUs have to develop their own resource-loaded schedules based on each member's skill level and productivity and then share them with others to allow for comparison and the selection of alternatives that best suit multiple interests.

To make effective trade-offs and generate realistic schedules, planners need to adopt a more resource-centric view than they traditionally have. Resource-centric means that the schedule for each resource is the building block for the project and resources may be engaged on multiple projects. This view is contrary to the view adopted by many web-based project management systems on the market today, which are project-centric. Other researchers also adopt a multi-project view, as is presented here. For instance, Scherer et al. (2002) propose that each project participant plan their workflow within the framework of all projects s/he is involved in.

A PU's resource-loaded schedule may contain information about two types of resources: (1) dedicated resources and (2) shared resources. Dedicated resources are committed solely to a single PU on a single project. Shared resources are committed to more than one PU or to more than one project. Some shared resources may serve multiple PUs on multiple projects, which complicates the coordination problem even more. Shared resources may be project shared or company shared.

Project-shared-resources are resources used by several PUs, but not necessarily 'owned' by any. Examples are material hoists used by any or all on site, but also personnel such as project management staff (project engineers and superintendents), and space such as material storage areas, pre-installation and installation working areas, and access paths. Company-shared-resources belong to a specific owner who is engaged in several projects. Examples are equipment such as expensive hoisting equipment, large plotters, and personnel such as project managers and safety inspectors. This distinction affects who has a say and what objectives must be met in selecting from alternative resource assignments.

Information regarding which projects share a resource is tracked by the resource's owner or whomever obtained (e.g., rented) the resource, whereas information regarding which PUs share a resource resides in a production schedule of each PU. In order to ensure that assignments do not result in conflict, resource allocation needs to be checked across multiple projects and PUs.

Several difficulties exist in achieving this goal using current project (and production) management tools: (1) each PU must develop an appropriately-detailed resource-loaded schedule and make a significant amount of tacit planning knowledge explicit, (2) these schedules must be described in a common language so that they can be understood by others, (3) data for these schedules must be maintained in each company's database, while schedules are being coordinated, alternatives negotiated, and conflicts resolved, (4) data must be reliable and disseminated in a timely fashion.

3. WORKMOVEPLAN

3.1 Design Objectives

WorkMovePlan (Choo and Tommelein 2000a, 2000b), a computing environment designed to support distributed planning, allows each PU's planner to create their own schedule. WorkMovePlan's aim is to help project participants create more reliable schedules, in an effort to make the project delivery process more lean (also see www.leanconstruction.org).

The WorkMovePlan environment builds on Microsoft Access (Microsoft 2000a) and Microsoft Visio (Microsoft 2000d). Various forms in Access allow the user to input and manage a detailed activity list and resource assignments based on the Last Planner methodology (Ballard and Howell 1994, Choo et al. 1999). These activities can be directly imported from Microsoft Project (Microsoft 2000c) or they can be developed from scratch. The hierarchical structure of the activities allows the user to break them down to any level of detail. Since WorkMovePlan does not rely on a single person but instead relies on any or all production managers (superintendents and foremen) to enter information, the description of activities and resource assignments can get very specific. The link to Visio allows planners to geometrically detail space use based on space layout stencils.

WorkMovePlan captures data pertaining to multiple projects. A project-specific detailed schedule is automatically shared with other project participants using database synchronization technology. The PUs can then check for shared resource conflicts within each project and across projects.

WorkMovePlan maintains an offline copy of other PUs' schedules as well as its own. It automatically updates changes only upon synchronization. WorkMovePlan is portable and does not require a fast consistent Internet connection. It can thus be used by practitioners, including even those who do not have consistent Internet access to interact in real time with an online database.

Each planner can look at the detailed production schedule including space use on site (described later) for all project participants and determine whether they result in conflict. The planners then need to collaborate off-line with others to develop alternatives for specific conflicts and determine which alternative best meets the needs of those in conflict, of the projects they are involved in, and of their companies.

3.2 'Near real time' Data Sharing based on Synchronization

WorkMovePlan's distributed planning and coordination feature relies on 'near real time' data sharing, which is based on the technology called synchronization. Synchronization is defined as "the process of updating two replicas in which all updated records and objects are exchanged. The exchange of data between two replicas can be one-way or two-way" (Microsoft 1999).

Each WorkMovePlan is a replica that is two-way synchronized. Each replica's database contains two parts: one that contains private information and another that contains public information. Private information concerns the owner of the database. It contains information regarding its resources, associate costs, and the detailed schedule of each PU. This information is not exclusive to a single project since resources may be shared across multiple projects. The WorkMovePlan user can thus schedule multiple projects at the same time.

WorkMovePlan automatically generates public information by filtering out what is unnecessary to share, based on pre-set conditions. For example, Figure 1 shows the screenshots from WorkMovePlan for roof drain installation. The bottom portion shows the detailed weekly work plan for contractor 'Atlantic Roofs' as seen by its employees. The top portion shows the weekly work plan for Atlantic Roofs as seen by all other project participants. Accordingly, the private information names Gilbert Atlas as the PU and the exact hours (4.5, 8, and 5.5) he is scheduled to work. In contrast, the automatically-generated public information shows the name of the company the PU belongs to (Atlantic Roofs) and only the days (Wednesday, Thursday, and Friday) when work will be done. By making a commitment at a less detailed level to other project participants, the PU creates flexibility to carry out work within any part of the revealed duration. This is satisfactory as long as the output thus delivered does not to prevent others from performing their work.

Public information is the replicated part of WorkMovePlan (Figure 2). By replicating public information between all replicas of WorkMovePlan, schedule information regarding all PUs can be automatically updated. A similar data categorization is used in Microsoft Exchange Server (Microsoft 2000b), which can be configured to contain private- as well as shared information. The shared information can be created and viewed by any one who has been granted permission to do so. However, private information is accessible only by each so-designated individual and not by anyone else.

WorkMovePlan automatically synchronizes only information that is relevant to each project (Figure 3). The main reason for designing the database in such a way, rather than using a centralized on-line database, was that not all PUs have a consistent Internet connection. Despite recent advancements in information technology, project site offices rarely have high-speed Internet access, especially at the start of a project. Project managers have pointed out that their planning system has to be in place from day one (at the latest!) because once the project starts, it is very hard for them to learn and/or change procedures and support tools. Another reason is that many PUs are protected by company- and project-specific firewalls. These firewalls, in many cases, prevent users from taking advantage of the available full speed of their Internet connection. Should online planning tools be used during meetings, progress of the meeting would slow down to match the Internet connection speed.

A disadvantage of using synchronization technology is that data is not available to all project participants in real time. Project participants might not synchronize WorkMovePlan for some time, but still create their own plans based on obsolete data from others. This may result in conflict between project participants' schedules and create rework when synchronization takes place.

By keeping a copy of the 'near real time' information, i.e., the information that was available the last time the database was synchronized, the owner of each WorkMovePlan replica can still view the schedule information of others off-line.

4. EXTENDED RESOURCE PLANNING

WorkMovePlan extends planning to include space scheduling (Tommelein and Zouein 1993). A planner can specify site space needs on a day-to-day basis for labor, equipment, and materials in terms of work-, laydown-, staging area, or access path as needed throughout the execution of a work package, which is the unit of work assigned to a PU. WorkMovePlan requires the user to explicitly input information on resources that need to be considered during space scheduling (Figure 4). This space scheduling information is automatically synchronized in the same way as is done for other resources.

Default categories for space scheduling refer to material, equipment, and labor but others can be included as needed. Shape refers to the physical shape of the space required. X, Y, and Z refer to the dimensions of the needed space. Although three dimensions are specified, WorkMovePlan's space scheduling takes place in a 2-D environment.

2-D drawings (such as blueprints showing a site arrangement or a building floor) are widely available and space can be assigned easily in 2-D. 2-D layouts convey space scheduling information in a straightforward fashion. They are crude but adequate for this application. Nevertheless, the height dimension entered by the user can later be combined by WorkMovePlan with the layout schematic to generate a 3-D virtual reality mock-up using the Virtual Reality Modeling Language (VRML 1995). Figure 6 shows a sample VRML model that is automatically generated from WorkMovePlan.

The default schedule for space use is from the start- to the end date of the work package, but it can be adjusted to represent other realities, such as the delivery of materials a day prior to the start of the work package. Once all resources to be assigned are specified, their positions can be selected using a graphical user interface (GUI). WorkMovePlan builds on Microsoft Visio as the GUI for space scheduling. All information generated within Visio is captured by WorkMovePlan and shared across all project participants. Planners can view other participants' space use when scheduling their own space use. Choo and Tommelein (1999) describe an example application of WorkMovePlan.

5. CONCLUSIONS

The ability to build realistic schedules for projects as well as for individual PUs depends heavily on being able to collect and distribute reliable information. The most reliable information regarding resource characteristics (e.g., productivity and availability) resides with each PU. However, having information from each PU does not necessarily guarantee a realistic schedule unless the planning process itself promotes realistic planning. The realism of schedules also depends heavily on timeliness of the data being used. Each participant has to create and provide data to other participants with sufficient lead time to allow for conflict detection and resolution.

WorkMovePlan is a tool that helps to collect and capture such data, and it makes selected data available for sharing with other project participants. WorkMovePlan's ability to make detailed assignments in terms of labor, equipment, and space will allow project participants to generate more realistic schedules than they currently do.

WorkMovePlan suggests a very different way of coordinating project participants as compared to what is done in current practice, which includes numerous 'throw-away schedules' that so many PUs generate today (Russell and Froese 1997). Resistance is expected when a new planning paradigm is presented. Choo and Tommelein (2001) discuss several barriers to adoption in industry practice of the Last Planner methodology and the WorkMovePlan environment. It remains to be seen whether the industry will widely embrace either one or both. In the mean time, additional research is to result in better tools for job-shop scheduling, multi-objective decision-making, and heuristic optimization, which can then be integrated with WorkMovePlan.

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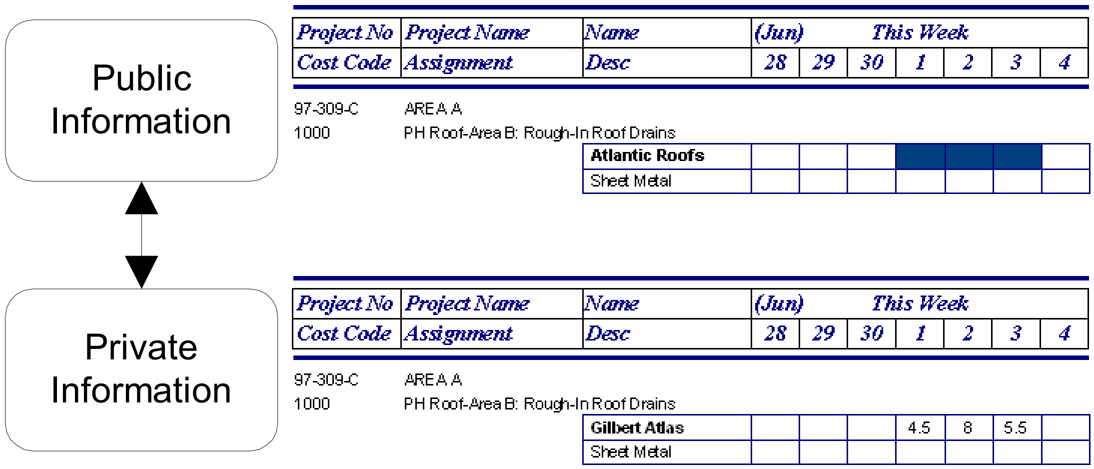

Figure 1. Relationship between Private Information vs. Public Information

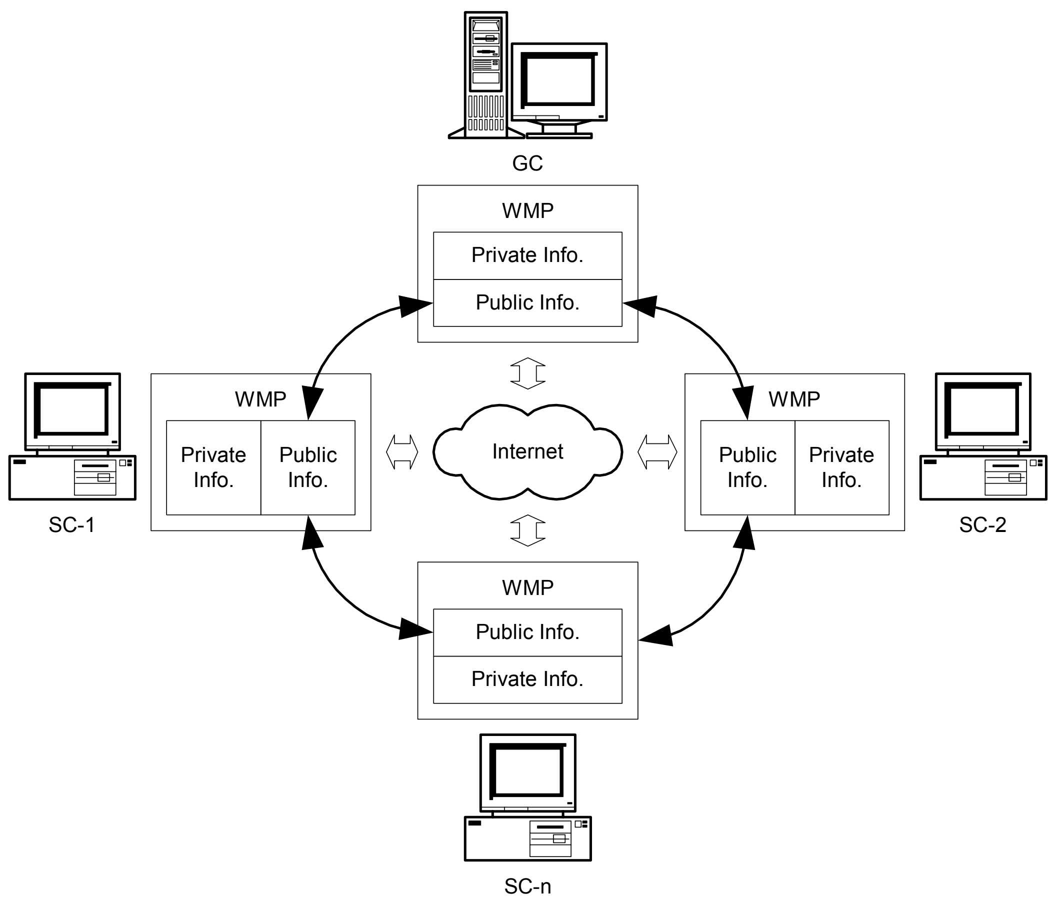

Figure 2. WorkMovePlan (WMP) Synchronization Scheme

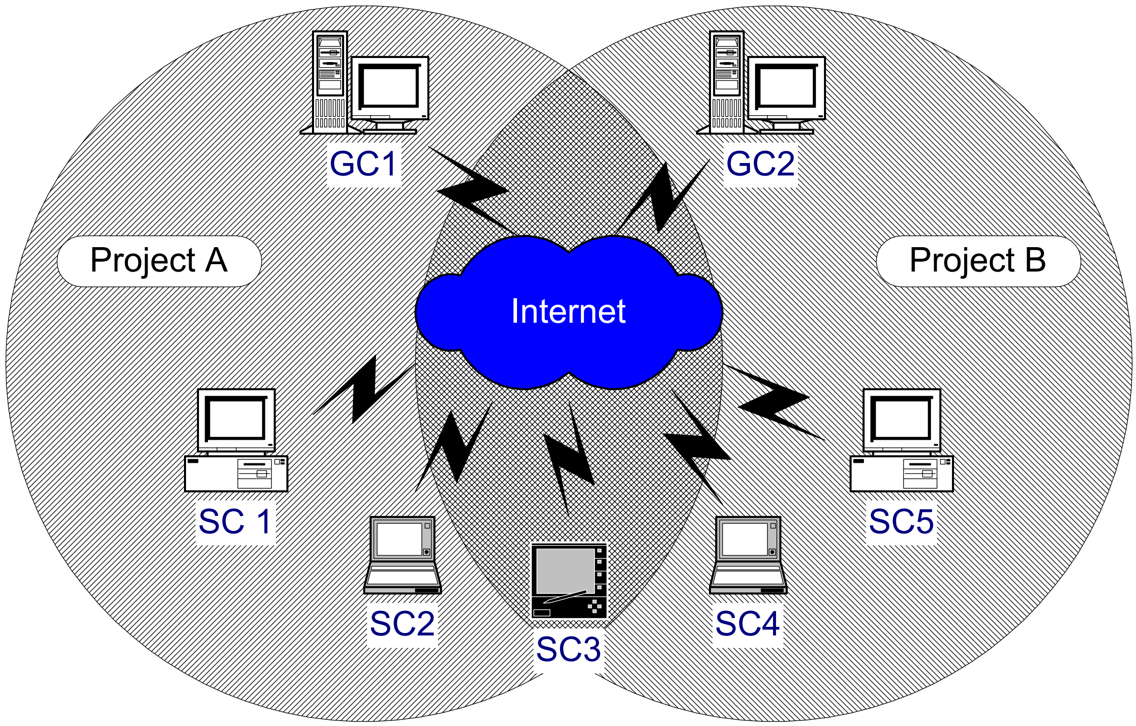

Figure 3. WorkMovePlan's Multi-project Scheduling Scheme

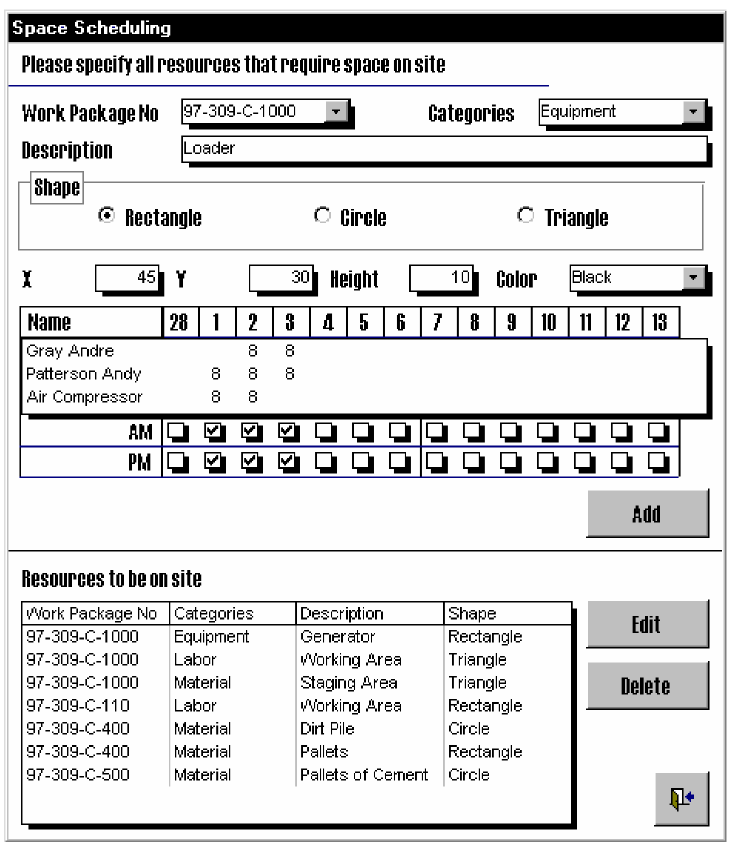

Figure 4. Space Scheduling Screen 1

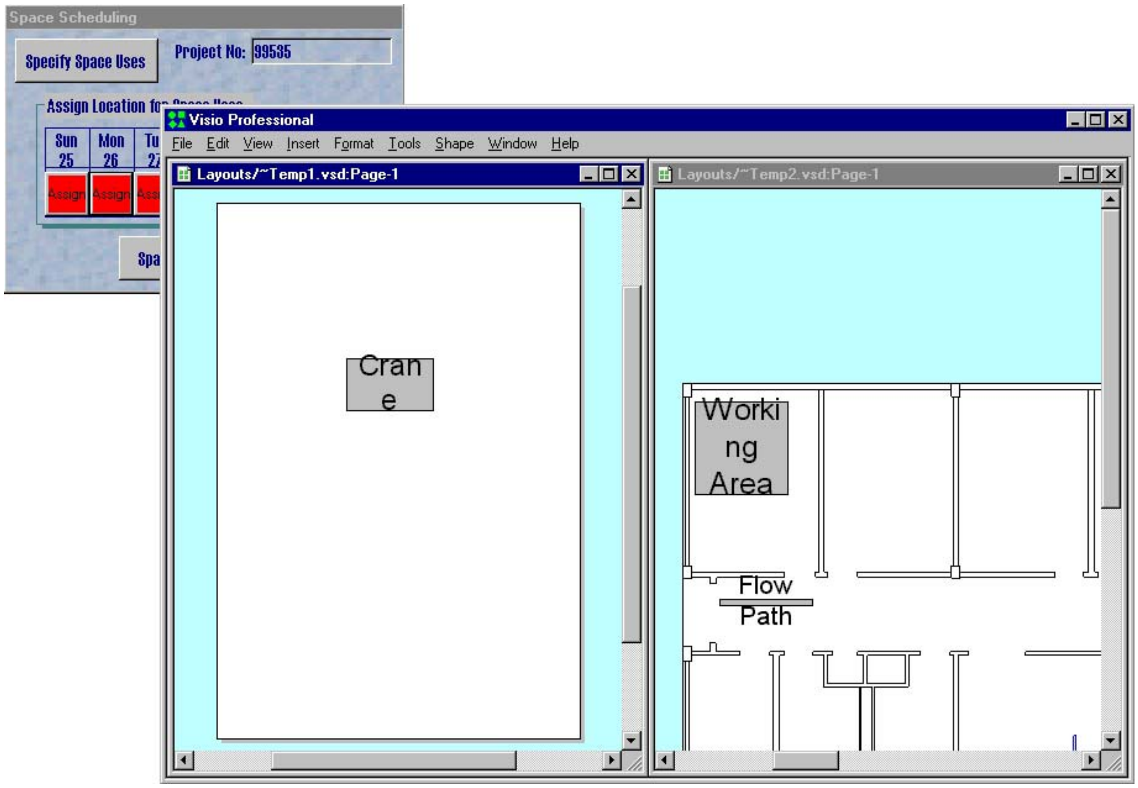

Figure 5. Space Scheduling Screen 2

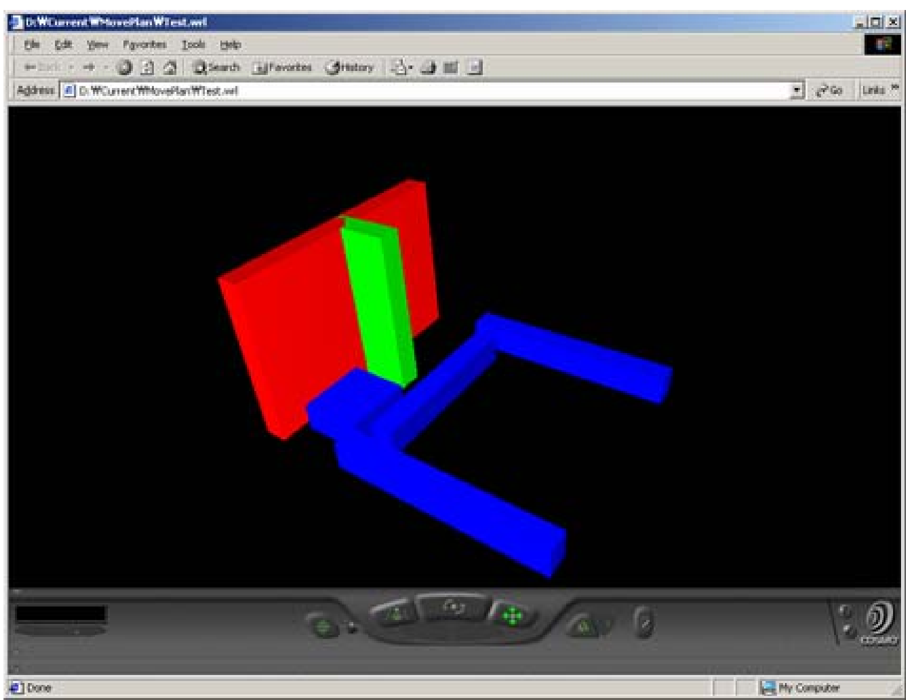

Figure 6. Sample Site Layout using VRML