

Virtual Worlds = Architectural Design + Computational Elements

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Abstract

A virtual world is a multi-user networked 3D virtual environment. Most virtual worlds have been developed for the entertainment industry, but we are beginning to see virtual worlds for educational and professional uses. These worlds draw on our experience in the physical world and mimic many of the forms and activities from the designed physical world. We can consider a virtual world as a composition of architectural metaphors and computing entities. The architectural metaphors are useful for providing a sense of place and, if multi-user, a sense of awareness of others. We have developed the use of virtual worlds for education and gained experience in the potential functions of virtual worlds for collaborative work.

As an assembly of computing elements, virtual worlds can have programmable functions to support various online activities. Current 3D virtual worlds on the web are largely static. The world's creator can make changes to the world but only in special cases can the users change the world or the world can change itself. Such a restriction makes these 3D virtual worlds useful for modeling existing designs but less useful as an environment for ongoing professional activities. There are two levels at which modifications can occur: the user can directly change the world through their direct actions, and the world can modify itself as a consequence of the user's actions.

In this paper we focus on the use and extension of a virtual world platform, called Active Worlds, and its relationship to architectural design. This platform focuses on the implementation of interactive 3D models. In these virtual worlds, a person is represented as an avatar that can interact with 3D objects to build, teleport, animate, etc. In this paper, we review some design principles and show examples of interactive virtual worlds designed by students at the University of Sydney in Australia and MIT in the US.

Introduction

An analogy between virtual worlds and architectural design is based on the view of the virtual world as a design of a place, where the designer specifies and organizes meaningful spaces and objects, reflecting some social and cultural needs and values in a particular form. Such a view assumes that the concepts of a physical building and a virtual world have some commonalities and some relevant differences. The interface between the virtual and the physical world has been explored by Mitchell in *City of Bits* (Mitchell, 1996) and *e-topia* (Mitchell, 2000). In this paper we explore the metaphorical design of the virtual world so that it builds on our knowledge of the physical but maintains that the virtual world has its own characteristics and requirements.

Physical architecture is created in the context of geographical space. Physical places are designed by specifying their size, shape, materials, and their spatial relationships. People understand the function of buildings and rooms through their experience in using them. In virtual worlds, designed places do not exist on a geographic site as traditionally understood. The establishment of a sense of place is achieved by creating a visualisation that is similar in some way to the physical world. People learn to inhabit and work in virtual worlds based on their expectations and experiences in the physical world. Novak (1990) develops an example of "instant" virtual architecture, free from the constraints of the physical world. However, the design of this environment resulted in abstract forms and spaces, which tend to be disorienting and distracting.

The organisation of virtual worlds, as well as physical buildings, should stimulate the development of a cognitive map to orient, work, collaborate and navigate in the respective spaces. For this reason, our virtual worlds have a similar appearance and semantics to the physical world. This builds on our intuitive understanding of objects in the 3D world, and extends the capabilities of the objects to have behaviours not possible in physical objects. For example, a virtual room can react to the user by

resizing the area of the room according to its use. We focus on the design of 3D virtual worlds in which a sense of presence of others is achieved using avatars whose visual reference is first person where the camera location is in the head of the avatar. The use of real time rendering makes it possible to create 3D virtual worlds that can simulate the effect of walking through a physical environment and reacting spontaneously to the use of the place. This is in contrast to the 3D models that have prefixed animation or camera locations and do not support spontaneous collaboration within the 3D model.

We have designed 3D virtual worlds and considered design issues related to education and professional activities (Li and Maher 2000; Maher, Gu, and Li 2001; Gu and Maher 2001; Maher and Gu 2001; Maher, Simoff, Gu, and Lau 2001a and 2001b). These examples exist as designs only, and were not implemented in a virtual world platform that allowed us to explore their function and behaviour. As part of research in computer-supported collaborative design, we have developed a virtual campus as a prototype virtual world for education (Maher, Simoff, and Cicognani 1999; Maher, 1999). This virtual world did not have a functional 3D interface and therefore explored the functional and behavioural aspects of virtual worlds.

In this paper we focus on the design of virtual worlds for professional use by example. We start by describing the virtual world platform as a combination of architectural and computing elements. We propose design principles of a virtual seminar room through two examples. Then we highlight some design principles through examples of student designs in which the use of virtual space and simple interactive behaviours create a new kind of place.

Virtual World Design Space

The virtual world environment that we are using to explore design principles is Active Worlds¹, a multi-user 3D world implemented to work on the internet as a client-server application. The server maintains the world model and data and the client displays and renders the world for each connected user. The world is 3D where the objects are located on a grid in a world with a ground, a skydome, and a background panorama. A person is represented in the world as an avatar which locates their view of the world and provides a sense of awareness of other people in the world. Figure 1 shows the layout of the client, where the 3D window provides for most of the interactivity, a chat window facilitates conversation, a web window complements the 3D world with media such as text, images, movies, etc. The other portions of the client window support a variety of navigation and communication activities.

¹ www.activeworlds.com

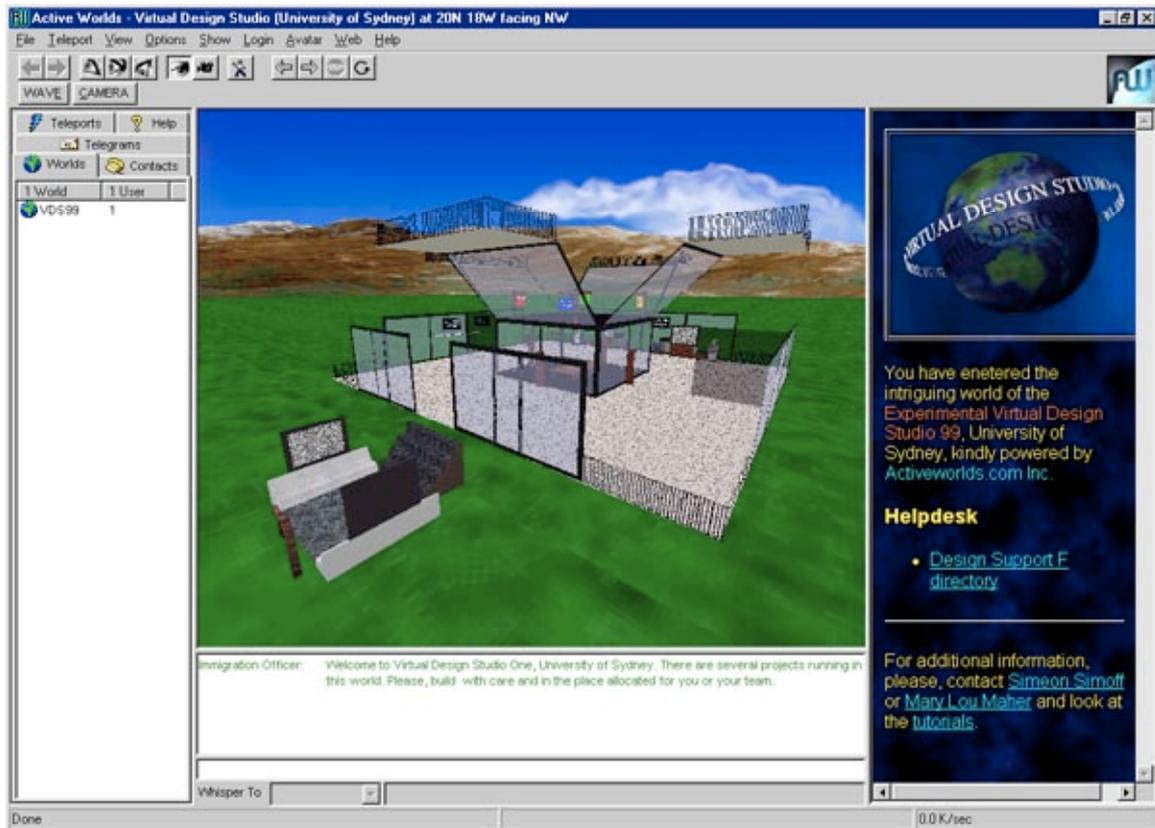


Figure 1. Active Worlds as a virtual world platform

The design space in a 3D virtual world, that is, the space of alternatives from which components are selected and aggregated, has two major categories of elements:

1. 3D models of objects to be part of the world
2. behaviours of objects that provide simple and aggregate behaviours of the world

This design space can be understood in terms of design prototypes as introduced by Gero (1990). A design prototype is a formalism for defining or describing a design space. Gero presents the basic design prototype as having 3 major components:

1. Function: the intended purpose of the design
2. Behaviour: the performance of the design
3. Structure: the geometric and materials specification of the design

In the design space of virtual worlds, the function of the virtual world and its components are the intended purpose, for example the seminar room is intended to provide a place for people to meet and discuss specific topics. The behaviours of the components of the virtual world are the programmed computing elements such as teleporting the avatar when it walks through a threshold space. The structure of the virtual world is an aggregation of 3D models of the objects within the world. Since the design of the virtual world is metaphoric (see Li and Maher, 1999), that is, we are not designing physical rooms but metaphorical rooms, the mapping from the FBS model to the virtual world assumes the metaphorical structure of the objects in the world rather than the physical structure of the bits encoded by a programming language.

In the Active Worlds platform, the design space for the structure of the world is a library of 3D models categorised according to a set of architectural categories of objects. For example, an object can have a 3D model selected from one of the following categories:

- Walls
- Arches
- Panels
- Floors
- Tables

- Chairs

A designer can add to the library by creating additional 3D models and adding them to the library. These 3D models become the building blocks for a new design.

In the Active Worlds platform, the design space for the behaviour of the world is a set of triggers and actions. A trigger specifies when a behaviour occurs and the action is the specification of the behaviour.

The set of triggers in the current version of AW includes:

- Activate: the action occurs when a user clicks on the object
- Create: the action occurs when the object is loaded from the server to the client
- Bump: the action occurs when the user's avatar bumps into the object

The set of actions in the current version of AW includes:

- URL: a web page is loaded in the web window
- Image: an image file is loaded on a designate surface of the object
- Texture: an texture file is loaded to wrap on all surfaces of the object
- Light: a light object is created with dependent to the original object.
- Teleport: the avatar is relocated to another point in the world
- Warp: the avatar is moved to another point in the world more slowly than teleport
- Visible: the object becomes visible or invisible
- Animate: the object performs a series of animation
- Name: allows the trigger to cause an action on a named object other than the object that is clicked, created or bumped

Since the alternatives for structure and behaviour can be combined in any way the designer wants, we can conceive of a two dimensional design space in virtual worlds as illustrated in Figure 2. Along one dimension we can select a 3D model for an object, and in the other dimension we can select a behaviour. This view of the design space highlights that a virtual world is a combination of architectural and computing elements, and that the designer ascribes the behaviour to the 3D object in a virtual world. This is in contrast to the design of the physical world in which the behaviour of the physical objects is causally related to its material and form.

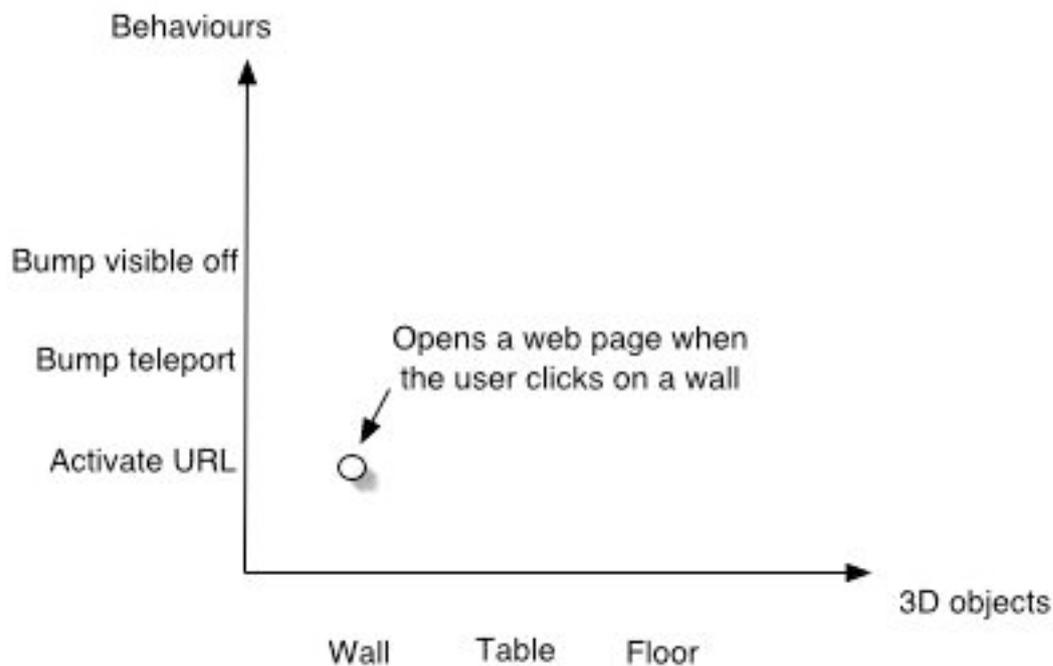


Figure 2. Design space for virtual worlds

Virtual Seminar Room Design

We have designed two seminar rooms that highlight a set of design principles for professional virtual worlds. Many of the existing virtual worlds are designed to be computer games where the focus is on competition. We have developed our own design principles for the design of virtual worlds whose primary function is to facilitate communication and visualisation for collaboration. We demonstrate these principles in the design of a seminar for a specific group of people that meet every week for a seminar discussion as part of their university course, and in the design of a general purpose seminar room for a consortium of research and industry partners.

Figure 3 shows the seminar room for a course taught at Columbia University and MIT. The students in the course came together from two universities at the same time each week. Since the universities are located in different cities, the contact among these students was primarily through the time spent in the virtual seminar room. Each student's presence is represented by their avatar, indicating both their presence and location in the virtual room, and by their photo. The design principles we have developed for this kind of seminar room are:

1. The walls of the room define the visual boundary of the space that is the room, thereby creating an inside and outside for the room.
2. The table in the centre of the room provides a focal point so that the students' avatars are facing each other, in order to facilitate conversation and orientation.
3. The documents on the table provide the content of the seminar discussion for the current session, in order to focus the discussion on common topics.
4. The walls provide for storage of documents related to the course, such as slides, transcripts, photos of previous sessions.
5. The photos combined with the avatars identify the individuals that are enrolled in the course.



Figure 3. Specialised seminar room for a group of people in the same class

Figure 4 shows a general purpose seminar room for a collaborative research centre. This place is used by a different set of people each time. The principles listed above apply to this room as well,

except the room only includes information for the current meeting, where the seminar room for the course above maintained of record of the people and their interactions in order to build an ongoing community experience. The room is an oval shape where the walls provide a place for hanging information. Each side of the room is identical, so a person looking in one direction can see the same information as a person looking in the opposite direction. The central ring and the pedestals assist in placing people in a circle so their avatars, and therefore their view of the room, includes the view of the others in the room.



Figure 4. A general purpose seminar room

Student Design Examples: Virtual Amphitheatre and Virtual Library

In this section we present two student designs that demonstrate the principles of virtual world design in which the 3D model combined with behaviours creates a new kind of place that only makes sense in a virtual world:

1. An auditorium
2. A virtual library

The virtual auditorium provides a meeting/presentation place for groups too large to fit in a seminar room, shown in Figure 5. Since the 3D virtual world is based on the location of 3D objects in space, the rooms have to be designed for a certain number of people. A seminar room is not very effective if the avatars are crowded so that you cannot distinguish one from the other. The auditorium design uses the concept of “speakers” and “listeners”. A “speaker” is teleported to the front of the room by clicking on a free speaker location. This makes it easier for people to identify who is speaking and to read their words over the avatar’s head. A listener is teleported to stand in the audience area, graded to allow avatars to see over the heads of those in front of them. The “speaker” and “listener” objects provide a visual reference to a location in the room through the 3D model, and each object has an associated behaviour that relocates an avatar to a speaker or listener position in the room.

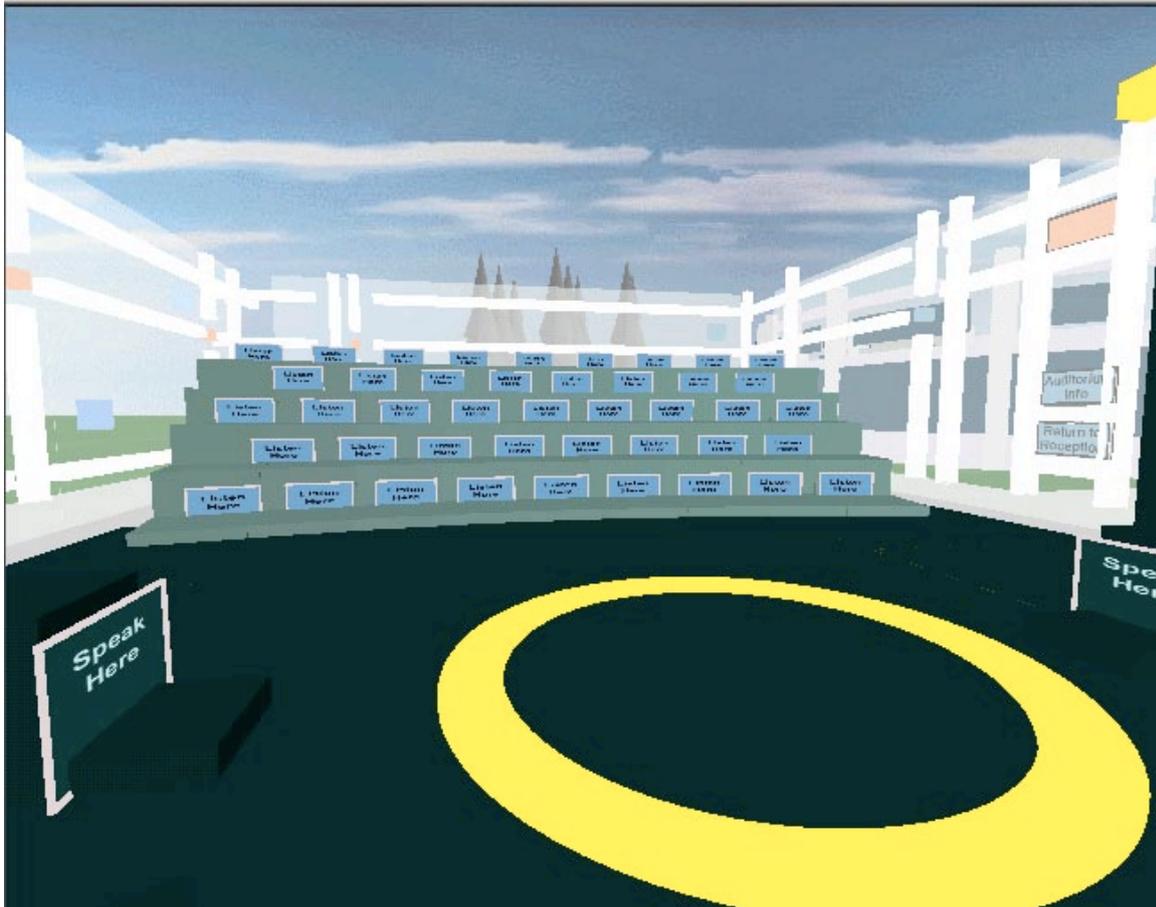


Figure 5. An auditorium designed for large groups

The virtual library provides a place for individuals to find information in a 3D space that reorganises itself according to the needs of the person in the library. As shown in Figure 6, the library has walls to provide a visual boundary, with panels on the walls that provide links to additional information in other media through the web window. The selection of the 3D objects as panels and signs organised in the shape of a room, creates a 3D interface to information. When the user enters the library, the room senses the user's presence and updates the panels to include links to the latest news. In the research room of the library, the user can interact with the information panels to customise the information presented on the panels. For example, one panel contains a map. By selecting a place on the map, the information panels present the current information that is relevant to the selected country or region. This is implemented by associating behaviours with the 3D objects that cause some information panels to be visible or invisible depending on the interests of the person in the library.

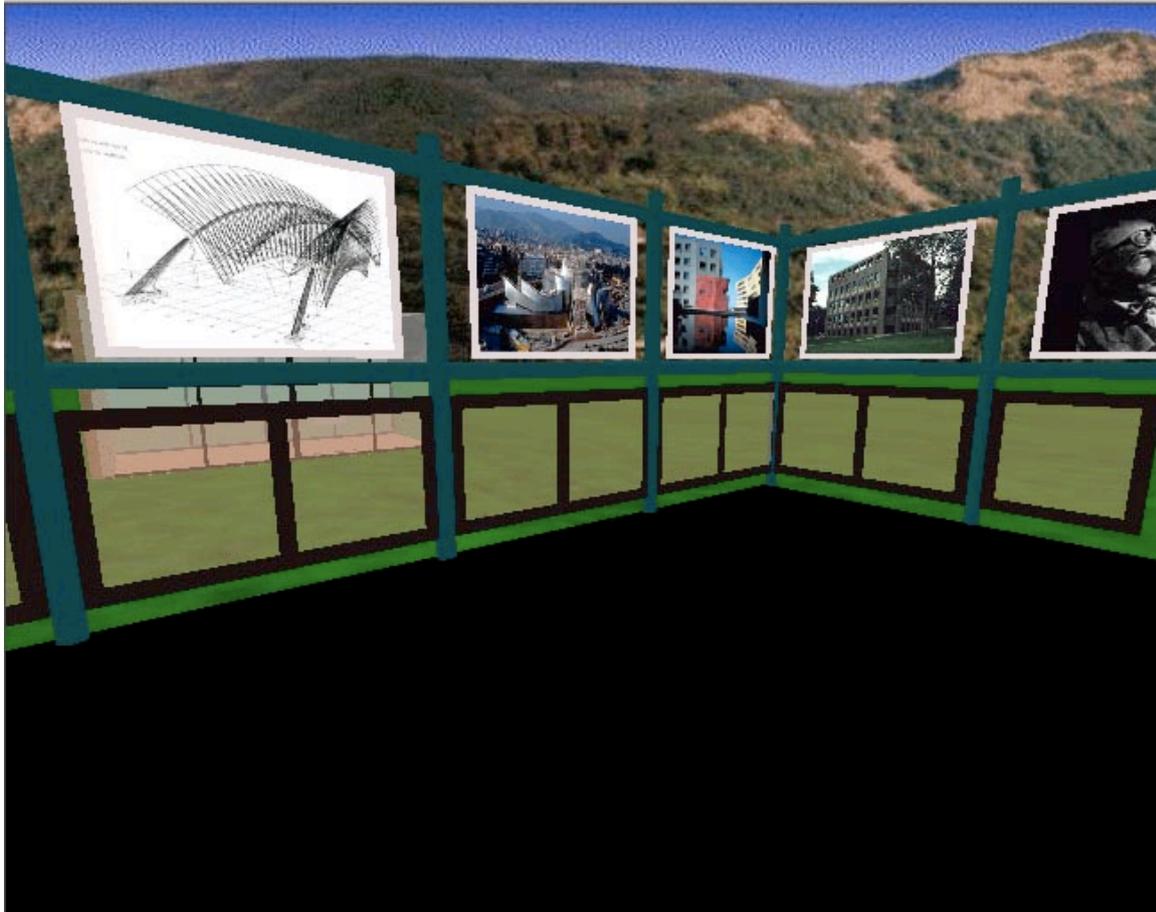


Figure 6. A virtual library

Conclusions

The design and use of virtual places as professional environments has highlighted some of the principles of a new area called virtual architecture. Virtual architecture allows us to consider the design of virtual worlds as places in some ways similar to places created through architectural design. A major difference in these designs is that we can combine components in a 3D spatial environment with computational behaviours. This creates a new kind of design space in which we have the 3D objects as one aspect of the building blocks and we have the objects programmed behaviour as another aspect of the building blocks. Our current research is looking at the incorporation of rational agents to represent the behaviours of the objects, where the Active Worlds platform supports preprogrammed behaviours (Maher and Gero, 2002; Maher and Gu, 2002).

There are three major conclusions from the examples and principles presented in this paper:

1. **Beyond being there:** these kinds of place environments demonstrate their potential when we can create places that go “beyond being there”. This is possible because the world is a virtual world and not constrained by the physical, but also because we can ascribe behaviours to objects in the world that are relevant to being in a virtual place.
2. **A new set of design principles** can be developed that consider requirements that are associated with the experience of virtual presence as well as the way in which a person interacts with a world through the input devices of a keyboard and mouse. These principles are only starting to be realized and each designer will develop their own design style based on how the designer interprets virtual presence.
3. **Metaphorical design** is an important consideration in the design of virtual worlds. Until there exists enough examples of virtual worlds so that we can develop an intuition on how to interact and behave in these new worlds, there needs to be a clear reference to the physical world. This provides a comfort zone for people interacting with each other and the virtual world.

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