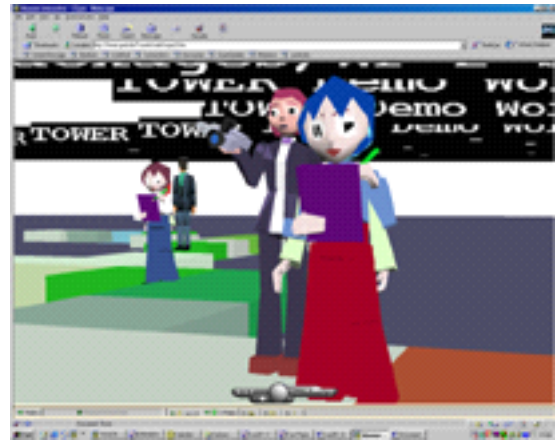


poster



# awareness of cooperative activities in mixed realities

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## Abstract

The TOWER environment creates, in parallel to the usage of groupware, a so-called "theatre of work" supplying awareness information. When performing an activity using a groupware application, avatars and their symbolic actions on the virtual stage represent the users and their current actions on shared objects. Avatars of users who work in a similar context appear spatially close in the theatre of work. The scenery of the stage is generated from the artefacts shared through the groupware application. The groupware application and the theatre of work are interconnected by means of the internet based TOWER event infrastructure. The theatre of work is presented as a multi user 3-D world on ambient displays in a user work setting to provide awareness of cooperative activities in mixed realities.

**Project URL:**  
<http://tower.gmd.de/>

## 1. Introduction

In a co-located team, members typically learn from a wide range of cues about the activities of the other members, about the progress in the common task and about subtle changes in group-structures and the organization of the shared task environment. Team members act based on their individual awareness of the current environmental and social situation. Most of this awareness is achieved without specific effort. A distributed (virtual) team – even if its cooperation is

based on a state-of-the-art groupware system – today is far from a similar level of awareness and opportunity for spontaneous, informal communication. This reduces the effectiveness of the joint effort, and makes cooperation a less satisfying experience for the team members.

Organisations are more and more restructured around virtual teams. Thus "they loose opportunities for innovation through the causal sharing of knowledge and learning induced by physical proximity" [17] or as Prusak [13] describes this phenomenon vividly: "If the water cooler was a font of useful knowledge in the traditional firm, what constitutes a virtual one?"

The TOWER system aims to bring the wealth of clues and information that create awareness and cohesion in co-located teams to the world of virtual teams and to present them in a 3-D virtual Theatre of Work. The 3D-environment provides virtual closeness related to the closeness of work items, tasks and contexts. It provides awareness about events in cooperative activities.

A number of approaches [14], [8] exist to support awareness information in groupware applications. Common to these approaches is that they concentrate on the provision of awareness information at the users desktop. In contrast, TOWER provides a virtual shared 3D environment, i.e. the theatre of work where awareness information is symbolised. Avatars and their symbolic actions represent users and their current actions on shared objects while using a groupware application. The avatars perform symbolic actions that illustrate events in an information space, episodes of interaction or non-verbal behaviour.

In the following we will give some theoretical background and requirements for a virtual awareness environment based on theories for human activity performance and relationship to environments. Then the generation and the components of such a virtual world are described. Finally a view on the potentials of the TOWER approach is given.

## 2. Effects of shared settings on group work

From activity theory [6, 7] we know that human activities are guided by inner-individual motives which may be stimulated by external objects. Like seeing a restaurant stimulates a motive for eating and activates an eating activity. In order to satisfy a motive, i.e. the need behind a motive, actions have to be performed. Actions are guided by goals. The execution of an action requires a plan of operations to be performed. The plan as well as the operations have to be adjusted to the environmental conditions. Before and after executing an operation, an actor has to verify the environmental conditions and to adapt her plan.

Real world settings are often designed to support particular kinds of activities, like restaurants, warehouses, schools etc. Barker's Behaviour Setting Theory [1] gives details of structural similarities between the physical properties of environments and the behaviour of its inhabitants. Social and physical forces combined with physiological processes, physiognomic perception and mutual learning are essential factors, that determine the synomorphy between the properties of a setting and the standing patterns of behaviour of its inhabitants [3]. Similarly, electronic environments should facilitate situated actions of the individuals [16].

## 3. Acting using groupware applications

In most groupware applications, social forces are limited by the low level of social presence [15]. Situated action and co-orientation are limited by the fact that members of non-co-located team do not act in a shared environment. Each team member acts in her own local setting which is basically constituted from the environment given in the local office and by the electronic environment as provided on the personal desktop and by the groupware application.

However, the shared "situation" of the cooperation partners lays in the groupware application and the shared artefacts. These constitute a shared virtual environment and which should be made visible.

The 3D-TOWER world visualises the shared context as a shared setting on a virtual stage. It is generated from the shared objects and contexts used. Functional distances between artefacts appear as distances in the 3-D visualisation. The operations of the users still take place in the local environments and by means of the groupware application but they are visualised in the 3-D virtual stage. Electronic sensors may be attached to relevant instructions and record awareness information. The stage displays the shared setting, the artefacts, the actors and actions that are taking place. The visual perception of the stage can be used by human actors to adjust their behaviour to the conditions displayed. In particular motives for activities can be stimulated and action plans can be adjusted to the scenery on the virtual stage although the operations still take place in the local physical settings.

## 4. The TOWER environment

In the following the technical mechanisms to generate and support the virtual stage are outlined. A central part of the TOWER environment is the generation a 3-D world from the objects used in a shared working context. Sensors are provided for recording the events indicating actors, operations and objects. Electronic sensors can be associated to groupware functions. The actors are represented by avatars and located according to their point of action as indicated by current events. Based on a model for symbolic acting the avatars are animated according to the events the actors caused. The TOWER environment is tied together by the event and notification infrastructure that sensors events in the local work settings and that also supplies sensors to detect the objects in the shared context.

## 5. Generating the scenery

The space of the TOWER world provides a context-based distribution of activity information, where the context is defined by the spatial, organisational, task-related and personal environment of the cooperating users [5]. The space module of TOWER dynamically creates 3D spaces from the shared information and objects used in a group (Figure 1).

In real built environments, the spatial structure affects movement patterns by creating more and less strategic routes [11]. The evolution of a symbiosis between patterns of spatial structure and patterns of behaviour gives rise to the richness of the cultural experience of space at both the urban scale and within building interiors. By en-capsulating certain aspects of this kind of emergent process within a space generation rule-base the space module seeks to develop a characteristic spatial culture within TOWER. Rulesets are used to generate the scenery of the TOWER stage from the artefacts used by means of the groupware application [4].

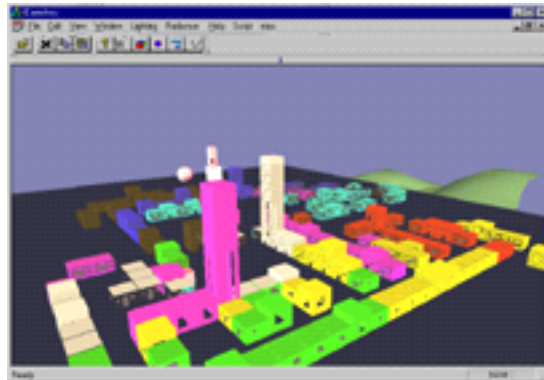


Figure 1: Creation of a TOWER world.

For example, a scenery of a TOWER stage is generated based on a BSCW shared workspace [2]. Distances between objects in the scenery map to topical distances between the objects in the shared workspace. The mapping algorithms and the rules used for world generation allow to tailor the scenery towards that desired by different kinds of organisation. For example, organisations with well-defined 'proceduralised' tasks and organisational structures may require more controlled and hierarchical spatial forms.

The space module of the TOWER environment provides the means which enables to construct a setting that carries and constitutes meaning in itself. In this sense behaviour patterns within TOWER are 'situated', the scenery visualises physical forces of the cooperation environment.

## 6. The actors in the scenery

In order to enable social forces and co-orientation, the actors and their actions are visualized by means of avatars animated on the virtual stage. The event notifications created when a user performs an operation are used this to animate her avatar. The movements of the avatar convey a symbolic meaning indicating the operation the user is performing. Symbolic acting provides a concept where the useful information of 'who is doing what' is displayed visually for the benefit of everyone without adding cognitive effort to the users [9].

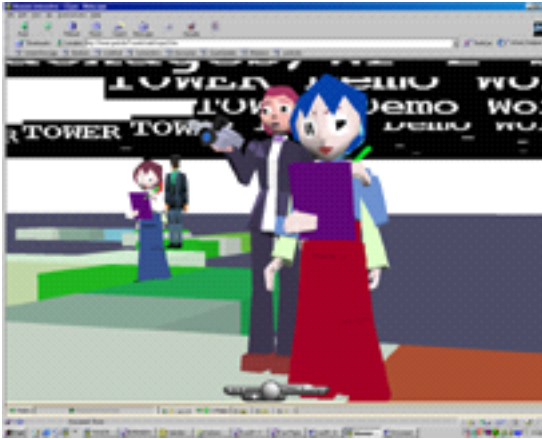


Figure 2: Symbolic acting in Tower

A user's avatar is located in the scenery at the place of her work, i.e. at the representation of the object she is currently working with. Thus depending on the object a user touches, her avatar will be moved in the 3-D world. According to the kind of operation she performs on an object her avatar will perform certain gestures in the virtual scenery.

By taking away the responsibility for controlling the avatar from the user and automating it we remove the problem of relying on neglect prone manual controls to add life to a world. With symbolic acting the context dependent actions of all users are shown at all times so the world can seem like a more active place as well as more closely reflecting the activities of a user group.

## 7. Interweaving virtual and real world settings

The heart of the TOWER system is the event and notification infrastructure that interconnects all components. It is the basis for world creation and for animation of the scenery.

The event and notification infrastructure is capable of recognising and sensing user operations on shared objects or in a shared environment [12]. This infrastructure is fully integrated with the Internet. Tasks of the infrastructure are to store, aggregate, and forward the event information to applications. Restricted access to event information is realised through access rights. Reciprocity mechanisms are included to ensure transparency between producers and consumers of information.

The scripts that drive the act in the theatre of work are derived from events that are generated by the cooperating users. Both worlds, i.e. the TOWER 3-D world and the physical interaction with the groupware application in the local setting

may run completely in parallel. The TOWER event and notification infrastructure interconnects both worlds and animates the scenery on the stage.

For a user, it is not necessary to be interconnected continuously with the TOWER world. Instead, when after some interrupts a user comes back to work in the particular group environment she may start the TOWER world. Then all events that have occurred since the last usage may constitute a replay of what happened in the mean time. Thus a time acceleration of the animation in the theatre of work may take place. This will enable a user to catch up what has happened in the meantime. Further means to reconstruct the history of the activities performed in the collaboration process by means of evaluating the past events are a matter of further study.

The TOWER scenery can not only provide awareness about events in the electronics work context but can also be interconnected with the physical environments. Relevant events in the electronic scenery can also be indicated to users in their local physical settings. To this end ambient interfaces can be established in the ambience of the local office. They are used as sensors to capture events in the physical environment or as indicators to indicate events from the electronic setting. Our research on ambient displays has been influenced by the work at the MIT Media Lab [18]. Similar approaches can be found in [10]. However, in TOWER ambient interfaces provide an interconnection with the physical and the virtual space in the 3-D-world. Ambient displays, which are integrated in the environment of the user, will help to avoid information overload by providing awareness information in the user's periphery.



Figure 3: TOWER in a user work setting

In a TOWER office setting the TOWER world is displayed either through projections in the office environment or by large touch sensitive screens. Figure 3 shows a office scenario in which the TOWER world is displayed at the wall. The user has just recognised the presence of remote colleague in the TOWER world indicating that this colleague is currently working on documents that are of interest to him. For opening a direct video connection to this partner he may now move the stage scenery on his screen and touch the colleague's avatar. This scenario shows the potential of the TOWER world to serve as a contextual chance encounter for distributed teams.

## 8. Conclusion

With TOWER, new workplaces will be opened which enable people to benefit from currently available animated 3-D world technologies for the development of new working situations for distributed teams. Distributed teams or groups will be the working conditions of the future. With the Theatre of Work we provide a pervasive environment that is complementary to existing groupware systems and that augments these systems to achieve an environment that increase the awareness and cohesion in distributed teams.

A user bodily performance takes still place in her local physical environment but it is mapped to the virtual stage. The virtual 3-D stage may facilitate cooperation, provide action affordances, and ease the development of congruent behaviour almost like a behaviour setting. Orientation in the cooperation process will be facilitated by the virtual stage.

The effects of the usage of TOWER on virtual teams, on team cohesions and synergy effects in team work as well as its impacts on telework and telecooperation will be studied in future practical evaluations of the system.

## 9. Acknowledgement

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