City Metaphor based Visualisation of Collaborative Work Spaces in TOWER

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Abstract
This paper describes the application of space syntax techniques (Hillier & Hanson, 1984; Hillier, 1996) for the development of virtual environments presenting TOWER, the Theatre of Work, which allows project members to be aware of project relevant activities as well as to establish social relationships to intensify team coherence (Prinz, et al. 2003). Different prototypes illustrate the evolution of the use of various rules for the creation of the Theatre of Work “stage”. Although the city metaphor has previously been applied in some approaches for data visualisation (Flavia, 1997), very little attention has so far of awareness and co-presence of users associated with thematically related groups of objects. Here we report on the implementation of space syntax derived conceptual models and illustrate associated implementation issues of dynamic information mapping in Theatre of Work stage visualisations. We further review user experiences of the system and discuss some of the limits in applying urban metaphors and space syntax techniques to data visualisation. We then point at issues raised by this approach that need to be resolved in future.

1. Introduction

TOWER, the Theatre of Work Enabling Relationships, aims at creating a shared environment to enhance team coherence and social presence in virtual teams. Its ambition is to convey a feeling of awareness and to support collaboration between team members. The TOWER world is a collaborative virtual environment, which offers a stage for social encounters and visually presents the work process in collaborative teams. Telling stories of the various patterns and histories created through collaboration forms an important part of TOWER.

Amongst the least convincing aspects of current virtual meeting and collaboration systems are the environments themselves. TOWER addresses this through the development of a space module which progressively creates 3D virtual spaces with a new dynamic mapping mechanism. These spaces then evolve in response to the patterns of collaborative space use and occupant interaction. In this way the TOWER environment develops a record of its own histories which in time acts as a powerful asynchronous device that helps users find their way through a project or work context; understand dynamic team structures and find each other. It serves to reveal social structures and information according to classifications based on the conceptual distance between participants, tasks and project contents. With this the TOWER environment complements the textual record of past activity in a more ambient and tangible form: by the creation of meaningful groupings and spatial relationships which in time evolve in the Theatre of Work “worlds”.

To achieve this, the Space Module within the TOWER environment applies some
of the core experience and models which have developed with observations and insights gained in configurational analysis of spaces at urban and architectural scale: It focuses on mapping and making visible evolving and changing configurational patterns in work spaces and social structures through time, all of which aid in our attempt to dynamically reproduce aspects characteristic of our real world “spatial culture” in otherwise culturally and socially shallow and unsatisfactory distributed virtual collaborative environments.

2. From Build Environment to Virtual Collaborative Spaces

The built environment is characterised by a series of complex interactions between the movement and static behaviour patterns of its occupants and artefacts. Man made artefacts, such as goods and particular buildings aggregate in specific spatial patterns situating potential interactions accordingly: e.g. the local market has fruit stands and a meat section, etc. The spatial order can be said to be tightly coupled with local cultural practice or in other words with “what we do, how and where” in daily life, work, for recreation, ceremonial and religious purposes. The spatial structure of our cities, its buildings and open spaces affects our movement patterns by creating more and less strategic or purposeful routes and relevant nodes in accordance to our desired interaction patterns and motivations. In turn others take advantage of our movement and interaction patterns by e.g. considering us as “passing trade” and strategically locating themselves positioning available facilities which we may require near our path or resting points. The evolution of a symbiosis between patterns of spatial structure and patterns of social interaction give rise to the richness of the cultural experience of space at both the urban and architectural scale. By encapsulating certain aspects of these types of emergent processes within a generative immersive visualisation, TOWER seeks to develop a characteristic spatial culture for distributed virtual environments. This approach has been used in TOWER to investigate how different “rule sets” affecting spatial configurations of work space representations can reflect and support organisational and intra-organisational networked collaboration. The emergent processes discussed here occurring in the real world are attached to issues of an individuals or groups territory, their privacy, accessibility, exclusion, safety, visibility, impact and transparency amongst others. They are predominantly social issues that are heavily negotiated and mediated through different configurations of space, public and private, at civic and building scale in a manner of structure and signified meaning. Each and every part of our urban environment provides different stages of more or less constrained and channelled interaction allowing us to have some type of impact on those around us or on the physical structure of the environment itself. The impact of our interactions in
turn reshapes our environment through time.

Workplace interaction patterns in organisations operate under those same constraints and create a particular set of staged interaction patterns. However, in extension a complementary virtual collaboration work space is difficult and problematic to create and inhabit precisely because the level of what is and is not possible in our interaction patterns is so poorly set out and staged, and so little of the impact of our interactions are subsequently becoming visible. Why is so? The reason is a dramatic change in the fundamental “rules of engagement and interaction” which we encounter in the electronic sphere of virtual collaboration:

Here we can be in more than one virtual “place” at any one time and we have the capacity to interact over distance asynchronously; with ease and much more range of impact than by phone or mail. Whilst this is the case, we do not have enough tangible feedback on our actions and it is difficult to see the full effect of our activity. In this domain, it may be quite possible to hide behind our own representations, manipulating and potentially misleading others. We may even choose to represent ourselves in inconsistent ways and could have more than one alias or avatar for each role we act out. At the same time we ourselves may be erroneously misrepresented by virtue of bad or insufficient systematic classification and categorization by third parties when our presence or actions are logged and communicated. In the virtual spaces we inhabit, reciprocity is not always guaranteed, i.e. if you can see me I don’t necessarily see you. This can be situation which sometimes leads us to take risks without being fully aware of them. Virtual collaborative work spaces may be visually distinct, but they tend to be dislocated and disjointed from any one physical space and local cultural idioms. Collaborative workspaces are not situated physically, but conceptually (i.e. by project, team, interest, information, etc.) and they often are self contained. Negotiating collaborative work spaces may require domain specific knowledge to understand where you are and what the represented context should mean to us. The membership in a given system is often exclusive and tightly managed which may lead to unwanted exclusion. Chance encounter becomes constrained to the membership of the existing participating community. Members can access collaborative work spaces from anywhere at any time without any apparent major physical effort, cost or time lag in movement. The concept of distance disappears and expediency of movement turns into an issue of usability and legibility of a navigational convention and transparency of the representational framework in order to facilitate a quick understanding of the given conceptual map.

3. TOWER Overview

We briefly outline the overall structure of the TOWER model and its components in response to these issues prior to focusing on the space syntax research inspired information mapping in the Space Module. The Theatre of Work “stage” is a generative and user inhabited 3D environment complemented by a variety of ancillary interfaces giving insight into the structure of networked collaborative workspaces (i.e. groupware systems such as LOTUS Notes, BSCW, etc.). It is therefore specifically bound to Internet centred collaborative work involving the exchange of digital artefacts such as text documents, multimedia files, databases within spatially dispersed teams. Core objectives in TOWER are the creation of awareness and co-presence of users among thematically related groups of artefacts to enable synergies between team members, supporting evolving social relationships and
increasing the value and potential of purposeful and meaningful interactions in relation to digital artefacts. TOWER is an attempt to provide means to mirror some real-world synergetic effects taking place in physical environments and support associated movement and navigation patterns and collaborative behaviour of people in their relation to situated artefacts. The TOWER environment aims to make co-presence, movement among and interactions with artefacts perceivable visually to facilitate traditionally encountered dynamic processes within a dispersed and asynchronous network setting.

Many collaborative environments in use today have primarily evolved from software engineering approaches to problem solving issues of collaboration online; only relatively recently have they taken increased consideration of the difficult social and cognitive problems involved such as awareness, presence, intrusion, visibility, legibility etc. as well as attempting to more comprehensively respond to the differing “rules of engagement” between the physical world and virtual environments.

TOWER is taking an approach that integrates several core strategies into the Theatre of Work “stage”. Activity sensors of different types located in the shared work spaces feed an event notification infrastructure; this in turn provides data to a symbolic acting system and a space module where generative rules are applied to map activity related avatar animations of participants and thematically situates digital artefacts in a number of joint representations within the Theatre of Work “stage”. This TOWER stage is comprised of a 3d multi-user environment, a set of optional ambient interfaces and a storytelling mechanism for the presentation of event and collaboration histories called docudrama.

The information mapping and visualisation is directly linked to the event notification system and the symbolic acting module (Figure 42).

4. TOWER Space Module

The role of the Space Module within TOWER is to construct the spatial representation i.e. the 3D immersive environment within which awareness and symbolic acting can take place. This construction is automated so that a minimum of user input is required in order to generate an environment that will be meaningful to a wide range of different end user organisations and types. The Space Module has therefore been created to provide a collection of tools that create a predominantly automatic process for the visualisation of collaborative activities within the networked collaborative workspace. A variety of visualisations may co-exist and complement each other based on different thematic aggregations of artefacts.

Users interact with each other and with artefacts in the collaborative work space, this in turn generates events which are received and routed by an Event Notification Infras-
structure [ENI] for shared awareness (Prinz, 1999). The Space Module is driven directly by this infrastructure: ENI publishes events in near real-time to other parts of the TOWER system describing user actions, interactions with artefacts and each other - such as creating or reviewing a document, a meeting event, etc. - as well as providing general status information within the TOWER environment. It is a means of tracking the statefulness of the collaborative environment at any one time. ENI thereby provides continuous, timed detail information on configurational and as yet unarticulated aspects of the system. Configurational dimensions in the system are primarily specific to the organisation and work structure in the collaborative teams that use TOWER and the symbols of artefacts its users converge on using on a regular basis.

The creation of awareness and presence for participants in a virtual collaborative environment requires at its core a way of registering and disseminating states, both of participants and artefacts within the environment, as well as their relationship to each other. Awareness is a matter of configurational knowledge of a system, i.e. the spatial, time and thematic distribution of artefacts, activities and participants. Presence is the degree to which participants, activity centres and artefacts are embedded within and visible and accessible to the entire rest of the system and its user community.

Accessibility and visibility of objects, activities and participants are thus crucial to collaborative work and can be significantly enhanced by thematic contextualisation and derived spatial aggregation. The Space Module creates a mapping to facilitate this visually in a progressively evolving three dimensional representation.

The Space Module system produces different types of output maps: The system primarily generates 3D worlds as VRML documents visualising document spaces so that they can be populated by avatars with the support of symbolic acting mechanisms. In addition to full three-dimensional output, the Space Module incorporates 2-1/2D java and a flash based output channels for more lightweight visualisations from a single user perspective. This variety of clients is supported by the use of an intermediate map encoding in XML schemas which facilitates different map output styles and simplifies development of associated software.
5. Information mapping & Placement Rule Evolution

We developed placement rules that take into account and manipulate the visibility and accessibility of artefacts relative to each other within a virtual world representation. The primary motivation in using space syntax methods and theories on visibility and accessibility was to make the immersive 3D visualisation of the collaborative work space “intelligible” to the users of the space, i.e. aid in creating awareness and presence of artefacts and users. To help us with this task symbolic acting behaviours in simple avatars would indicate whether user actions in relation to a document were reading, writing or some other activity. Symbolic acting also indicated if two or more people were working simultaneously on the same document.

This objective was not easy to achieve as we observed throughout our user testing that users of the system at times would work on multiple different aspects i.e. in different areas of a project work space at the same time. In the TOWER world visualisation this translated in avatars needing to be presented in multiple places at the same time. This multitasking pattern raised specific issues for the presence representation of users via avatars within the 3D environment in the symbolic acting system. We solved this problem by introducing avatar-proxies i.e. “ghosts”. Suddenly, we are able to literally be in more places than one at any given time by virtue of TOWER. A thorough understanding of user needs was decisive in helping us to develop the system further.

Our initial idea was to represent the information space as a small town or village, where documents and folders were represented as houses and the streets and squares in the city were the meeting spaces where people and their representations (avatars) could gather and have discussions, and be observed. To build these worlds we used Bill Hillier’s beady ring method. This algorithm provides each house with a piece of garden in front of it, the gardens are then connected so as to always provide space in front of the houses which, when there are many houses becomes streets.

We devised a system which was ranking incoming events according attribute similarity of user action or document to decide preference for placement of houses in the visualisations. Thus documents in the same folder or created on the same day could be placed near each other, or within sight of each other.

When a user action occurred in the workspace, i.e. some one down loaded, uploaded or edited a document; a new house was created in the 3D world. This would be placed next so that it adjoined gardens with the best match of all those houses which had an empty space around it. This was not necessarily closest to the best match achievable, but still more likely to be at the edge of the city. For this reason we decided to add a second stage to the placement algorithm that periodically reordered the city to allow pairs of houses with high similarities to be moved closer to each other - and in a variation of the algorithm - for lines of sight to be opened up between those sets of houses. This algorithm used a dynamically processed version of visibility graph analysis; incrementally identifying connectivity - a step at a time - moving forward perhaps only by one house so that the overall shape of the city would not change to quickly in the restructuring process. (Figure 43)(Figure 44)

Initially on entering a TOWER world visualisation user avatars appeared at ground level, in streets of continuous gardens in front of the houses. It was quickly found by our user groups that documents in this representation metaphor were hard to find when navigating and searching the city at ground level. We then experimented with placing avatars at roof height to make them more visible from a distance and thereby also give
Figure 43: Clustering Rules & Intervisibility Testing, Geometry Relocation

Figure 44: Document Clustering aggregating concentrating research projects from particular establishments in common areas; (Building Research Establishment workspace visualisation)
users steering their avatars a raised field of view. This called into question the concept of
document representation via houses with front gardens.

Usage of the system was generally so low that chance encounters were sufficiently
infrequent to not induce many chance gatherings or meetings and browsing or searching
of the world for documents by individual users was the predominant pattern of use. The
initial attempt of incorporating avatar meetings within the information space gave way
to the idea of observing the information space and its usage. The users stopped operating
as pedestrians with a constrained view during the navigation and review process to act
more like “gods” in the sense of an all powerful concurrent overview of the world and as
town planners by giving users choices in representation metaphors for artefacts. Whereas
before we were only representing actions as they happened to users locally to their avatar
location in the world, now we wanted users to be able to view the entire information space
at one glance to immediately provide zooming overviews of any actions on the project
areas and interactions between members.

For this we devised a different generative rule set which would enable users to reorder
the collaborative work space in different ways in 3D. We enabled users to set their own
priorities on the assessment of document or folder similarities by ranking and prioritizing
particular attributes, with low scores pushing objects apart and high scores moving them
closer together. We gave users a choice to select which attribute they wanted to represent;
be it actions, documents, or folders and the way in which subsequent reuse of the objects
themselves were visualised. For example this would be done by objects increasing in size
or the addition of extra marker symbols above an object. (Figure 45)

At this point the data set visualised in the given TOWER world usually would be a
reflection of the existing shared folder hierarchies created for specific projects in the group-
ware collaborative work spaces. Because these data sets were often quite large, the type
of grouping and visual aggregation became important for maintaining an overview of the
whole system. Viewing individual documents was starting to overburden the clarity of the
system making it less legible, but being able to see who was acting in what general project
area was found to be more practical. Configurable interfaces where then applied to enlarge
the “town planning” choices users had in modifying the representational metaphors and
placement rule weightings. This proved useful for experimenting with what was the most
useful representation for each particular workspace or interaction pattern. The representations became by experimentation more simplified geometries, i.e. flat tiles with smaller icons to represent different kinds of data. Importantly this allowed the avatars to be able to see each other and at the same time give a better indication as to their context. This was done using text, images and colour. At the same time we created a landscape around the information space to provide landmarks as to global location. Having made everything visible to everything else, we were then asked to visually separate thematically unrelated folders from each other. We did this by introducing trees placing them into empty spaces around groups of folders. (Figure 46)

Several approaches have been adopted regarding the identification of the documents: In order to be able to distinguish between the different documents and recognise their type, an image representing the mime-type was mapped on the documents. In addition, the document name will appear above each document to ease identification.

6. User Experience & Observations

Throughout development of TOWER, we engaged with different user groups who were actively using the various prototypes of the TOWER system. A number of observations in everyday use led us to alter a variety of aspects in the TOWER environment.

Navigation Perspective

In the beginning of the TOWER development, we were expecting users to steer themselves or selectively be steered around a TOWER environment automatically. As previously pointed out this was later abandoned in favour of a more continuous “birds-eye” view. This totally dropped the immersive navigational aspect of the TOWER user experience from the system as it was perceived as unproductive. TOWER worlds have objects arranged in groups representing documents and folders. Thematic areas of the represented folders and documents are indicated through the placement, iconic representation and proximity between them. Users can adjust the mapping of thematic clusters through configuration directives which result in altered representations in the TOWER world. During the early
prototype implementation a review was made of the meaningfulness of the resulting worlds. In particular it became clear that an overview of the world was needed if a user was to understand its layout, and that a zooming aerial view was therefore more practical. A new approach was suggested where representations of documents would not be given height, but would be coloured up tiles on the ground level of the world that would yield much greater overall visibility.

Consistency

We discovered, that we needed to limit the degree to which participant were able to alter a folder structure inside of a project workspace as too many changes and associated shifts in the configuration of the automatic representations were disorienting other users. Consistency in virtual worlds has presented itself as a difficult task as project work context tends to change quicker than we are able to follow easily in a spatial metaphor based on project folders. At the same time the fact that participants actively multi tasked and thus were able to occupy several work spaces at the same time presented us with a variety of new technical and conceptual issues which require further research.

3D versus 2/2.5D

The introduction of alternative interfaces onto the Tower stage helped us to we discover that from a usability standpoint 2/2.5D map visualisations were almost as effective as full 3D. This difference in particular was relating to the change from the more unproductive “active” navigation to a more birds-eye centric overview with zoom capability.
Changing the rules

[1] First we applied the beady ring model by Bill Hiller with gardens in front of houses representing documents. We allowed for avatars to move between individual documents. We discovered that users did not find worlds visualised in this manner particular useful. We had door to door visibility but avatars rarely saw each other. There was little reason and opportunity for interaction and it therefore did not get much active use. Generally, there was too little usage of the system to make it worthwhile for users to interact much. The literal mapping of documents did not sufficiently take into account the particular issues of intelligibility and accessibility of virtual environments during active navigation. [2] When we used VGA analysis to calculate connectivity exposing highly connected documents, the system more successfully managed to enforce thematic relations and intelligibility. Document attributes like topic, author, date, etc. were used for creating map connectivity. Although this improved model was supposed to reinforce accidental encounter in context we still had an “entry point” problem i.e. it mattered in terms of intelligibility where user avatars were initially placed on entering the world prior to navigating. We also still had issues particular with the limited number of immediately visible buildings from the ground level perspective. [3] At this point we changed from an active, ground level navigation initiated by users to the zooming and panning “birds eye” view as feedback had told us that no one was inclined to actively navigate a world which was not sufficiently intelligible both from a structural and perspective view. To simplify further we then shifted to use representations of folder hierarchies, at which point we were suddenly moving away from directly using physical metaphors to using abstract organisational structures [i.e. folder hierarchy, people were already familiar with]. Together, relations and patterns then became more visible.

Representation Patterns of usage and structure

Geometry became more simple as we moved from houses to tiles with file type icons with activity states being represented by applying scale and colour on folders with additional stacking geometry representing either views from different locations, or differentiating user actions such as reading or writing by creating a new colour slice on top of base objects. We effectively manipulated visibility of artefacts and actions based on the activity type and intensity on them through time.

Differing Organisational Needs

Further we discovered that organisations with well defined areas of work, interaction processes and organisational structure may require more controlled and hierarchical spatial forms in a visualisation than those used to more freeform and ad-hoc team structures and project work patterns. This results in the need for greater experimentation with different rule sets for the various types of collaboration practices and workspace visualisations which work for the broad range of needs.

7. Conclusions

Within the TOWER environment we have developed a generative information mapping system that provides a dynamic and configurable test bed for creating a variety of customized visualizations of collaborative workspaces and their associated user actions by
applying space syntax techniques. We have shown that it is possible to create context mappings of collaborative workspaces using an urban metaphor that is based on connectivity analysis of project themes and work area structures. We did however find that concepts of visibility, intelligibility and accessibility in the physical world do not always operate in the same manner as they do in virtual collaborative environments. Therefore the approach of extracting placement rule prototypes from observed emergent growth patterns in the physical world for the purpose of visualisation of virtual collaborative spaces needs to take account of these different “rules of engagement.” In particular, in future work we need to evolve a deeper understanding and better means to address how different navigational behaviours and the altered character of presence, awareness and interaction of users in dispersed information spaces requires a retuning of ‘real-world’ placement rules to make visualisations of virtual collaborative workspaces useful.

8. Future Work

We are looking to continue and expand the development of the TOWER Space Module Component in the context of the Bartlett School Intranet developments. More work is required within collaborative spaces with a large user base in order to test more operational aspects of the system. Some of the core 3D technologies deployed in the project for distributed immersive 3D have been in part superseded by other developments within the last two years which we are now reviewing in order to develop a new variation on the TOWER Space Module system. We are further investigating the integration and expansion of spatial ontologies in future versions of the Space Module.

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Literature


