Chronos: A Tool for Interactive Scheduling and Visualisation of Task Hierarchies

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Abstract

Visualisation and structuring of tasks in a schedule, from relatively simple activities such as meeting scheduling to more complex ones such as project planning, has been traditionally supported by timeline representations similar to Gantt charts. Despite their popularity, Gantt charts suffer from a number of shortcomings, including poor representation of detail and inefficient use of screen real-estate, particularly when a large number of parallel tasks, each of which requiring its own representation space, need to be displayed. We have devised an alternative visualisation, called temporal mosaic, which addresses some of these shortcomings while utilising space more efficiently. We have recently shown that as a static visualisation temporal mosaics outperform Gantt charts in terms of their ability to convey time-based scheduling information to users engaged in various temporal inference tasks. This paper extends that research by presenting interactive techniques which support creation, and dynamic visualisation of task hierarchies and relationships. These techniques are illustrated through a system for direct manipulation of schedules in both Gantt chart and temporal mosaic formats.

1. Introduction

The creation and management of large project schedules is a complex task which requires from the person (or, increasingly often, the group of persons) performing it a great deal of attention. A scheduling task is usually part of a broader planning process which involves, among other things, the identification of conflicts and bottlenecks, and the satisfaction of multiple constraints. Planning requires optimisation and monitoring. For most project management activities, the former is performed through the putative structuring of tasks along two axes: a timeline and a task execution hierarchy. The latter is performed through maintenance of a record, usually some form of coordinative artifact [4] such as a shared chart or table. Despite having been created over a century ago, Gantt charts [10] are still widely employed to support these kinds of tasks, and form an integral part of popular project management tools such as Gantt Project, MS Project and OmniPlan [18, 20, 25].

As part of project management software suites, the original Gantt chart has gained an interactive dimension and undergone adaptations designed to circumvent the screen real-estate limitations of the digital medium as well as take advantage of the medium's dynamic presentation capabilities. However, the chart's basic visual design has remained largely the same. In fact, some claim [26] that Gantt charts are really most useful when drawn or printed on large sheets of paper and displayed in common areas, thus highlighting their coordinative roles and preserving their ability to offer a comprehensive overview of the schedules they embody.

Part of the reason why Gantt charts have changed so little since they were first proposed is undoubtedly due to the intuitiveness of the original design, which is based on the natural ordering afforded by the timeline representation [28] combined with the anchoring of events on a spatial grid [27]. However, as Gantt charts took on additional plan and schedule creation roles, they began to require additional features beyond static visualisation. Although it has been argued that the static visualisation metaphor employed by Gantt charts carries through seamlessly to interactive contexts as more general forms of timelines [24], most work on dynamic aspects of timeline visualisation to date has focused on dealing with screen space limitations (though zooming, overview plus detail and focus context techniques [5, 11, 6]), or on enhancing the display to include visualisation of metadata in knowledge-rich domains [16, 2]. An issue which has received far less attention is that of implementing effective visual feedback for creation and modification of schedules (specially in terms of hierarchy manipulation and what-if analysis) by making the overall impact of moving a task, its sub-tasks and dependencies along the timeline immediately visible to the user.

We argue that the above mentioned issues are, however, interconnected. Effective visual feedback for editing and direct manipulation of timelines is only possible if the system
can provide a clear and space-efficient overview of tasks, so that time allocation and dependencies can be inferred at a glance. In previous work [19] we have proposed a *temporal mosaic* representation as a more compact alternative to timelines for visualisation of multiple event or task streams. In this paper we extend that idea by employing the mosaic display as a basic user interface element of a schedule creation and visualisation tool, called *Chronos*. This tool addresses the screen real-estate and immediate feedback requirements outlined above though several mechanisms designed to support focus and context awareness as well as overviewing of task hierarchies, attributes and relationships.

2. Related Work

In addition to their use as static visualisation in traditional Gantt charts, timelines have been extensively used in interactive systems [24]. Visualisation of temporal data finds natural applications in a variety of domains, including travel itinerary management [3], exploratory search [1], calendar scheduling [9], personal information spaces [15] and healthcare [14].

The LifeLines system [22] is among the most influential works targeting visualisation of temporal data. Compared with traditional Gantt charts, LifeLines has been found to be quite intuitive for medical applications, while providing for focus plus context in viewing data, and allowing for easy identification of patterns [14]. The system also allows grouping of similar events through “facets” which can be opened or closed to provide different aspects of the same information structures. Gantt charts, on the other hand, are capable of displaying hierarchical information, and are therefore better suited to project management tasks where the user needs to be able to view scheduling information for various tasks at different levels of detail. Both faceted browsing and hierarchical organisation have been used in exploratory search applications [1] which have gained some popularity on the Web. These include, for instance, Continuum [2] and MIT’s SIMILE timeline [12].

While the above mentioned systems focus mainly on the display of temporal data, other works have looked into the issue of creation and management of schedules. In [7] basic operations slice, overlay, filter, concatenate, new, copy and delete are defined along with a timeline browser to support manipulation of temporal data in the biomedical domain. This set of operations is extended in [16] which proposes a generalised framework including facets and metadata presentation. In both cases, however, the interface is based on a Gantt-style visualisation. This is also the case of the other systems reviewed above, the most prominent examples of which [2, 12] have been influenced by the framework proposed in [16]. In addition to these generic uses, timelines have also been adapted to support awareness of scheduling constraints [9] and augmented with user interface components for improved usability, including multi-scale sliders coupled with a focus plus context visualisation style [23] and non-linear sliders [13].

2.1. Temporal Mosaic

In [19] we argued that supporting visualisation of events or tasks for applications such as scheduling and multimedia browsing amounts to directly supporting a number of basic perceptual tasks. These include assessment of event and time interval properties such as, start, end, duration, and inactivity, as well as detection of event relations such as exclusions, overlaps, and subsumption. A system that aims to support interactive scheduling needs therefore to be able to support at least these basic perceptual tasks. We also introduced a temporal mosaic visualisation as an alternative to timelines. Briefly, the temporal mosaic can be seen as a concatenation of several parallel streams of a timeline into a single space-filling stream. Unlike a timeline, which grows vertically on demand, a temporal mosaic has a fixed height and allocates space proportionally to the number of overlapping tasks in the time interval spanned by the representation. This concept is illustrated through the charts in Figure 1, where the three temporal streams in the top box are equivalently represented by the mosaic shown in the bottom rectangle.

![Figure 1. Three event streams of a Gantt-like timeline and their representation as a temporal mosaic](image)

We were able to show that temporal mosaics outperformed Gantt-style visualisations as static representations in a series of user trials involving two distinct tasks: meeting browsing and a building project scheduling. Mosaic users did particularly well at tasks involving detection of concurrent events, inactivity and exclusion, while performance on tasks involving assessment of duration was practically identical in mosaic and Gantt-like timelines. Further details can be found in [19]. These encouraging results, allied to the space-efficiency of the temporal mosaic representation prompted us to design the system described below for dynamic schedule visualisation and manipulation.
3. Visualisation of Scheduling Tasks

In addition to the basic perceptual tasks supported by temporal mosaic as a static representation [19], a system for interactive editing and visualisation of schedules needs to support dynamic exploration at different levels of detail while preserving the user’s awareness of the overall context. Mosaic is particularly well-suited to meet these requirements, since its more compact representation allows us to preserve a graph’s global structure even as it is modified locally. These interaction requirements are presented in detail in the following sections.

3.1. Focus and Context Awareness

Perhaps one of the most important requirement of any form of visualisation is to support viewing and interpretation of data at different levels of detail, depending on the task being performed and the needs of the viewer of that data. This is particularly crucial for visualisation of time-based scheduling type tasks, where the data can often be complex, and can stretch over long periods of time.

Furthermore, when viewing or focusing on a set of data at a particular level of detail it is also important to be aware of the larger context or set in which that particular data set exists. In terms of scheduling tasks, for instance, when viewing and focusing on a specific task (or group of tasks), it is usually important to be aware of where that task is within the context of the entire schedule or some related part of it.

The most common approach to fostering focus and context awareness in interactive visualisation systems is to provide some form of zooming mechanism, and perhaps an overview of the entire schedule. These different views are generally shown in separate viewports (e.g., separate windows), thus requiring the users to change their views between multiple viewports when viewing tasks in focus or in context. An obvious issue which such visualisations then need to address is how to eliminate, or at least reduce, the problems associated with moving one’s attention between separate viewports, while at the same time keeping the awareness of the relationship between the data being viewed in focus and the larger context in which these data exist [11]. For timelines, specifically, this issue has been addressed by parallel presentation of multiple selections and zoom levels [23, 8]. While this approach can be effective for a small number of streams with no hierarchical dependencies, it does not scale well for more complex schedules. Although distortion-based techniques [17] can help preserve context, specially in situations where screen real-estate is at a premium [5], they are limited in terms of the amount of information they can handle.

3.2. Task hierarchies and relationships

Visualisation of hierarchies and the relationships between different parts of the data set being visualised is yet another issue related to the presentation of data in focus or context.

For scheduling activities, a common form of data hierarchy whose viewing should be supported by interactive systems at different levels of focus as well as context, is that of tasks and their individual sub-tasks. In timeline visualisations such as Gantt charts, tasks and their sub-tasks can be “folded” and “unfolded” to provide for viewing of data at different levels of detail. However, an obvious problem with this solution is that folding and unfolding tasks can in turn change the view of the resulting visualisation radically by shifting individual timelines up and down, thus making it nearly impossible to maintain focus and context awareness of the data being viewed, a problem often compounded by the phenomenon of change blindness [21].

Support for viewing of relationships other than task and sub-task hierarchies is almost completely lacking from most interactive timeline visualisation systems. The notable exception are systems that support faceted browsing [2, 16], but these trade support of general relationships for preservation of context, as the timeline changes, sometimes radically, when different facets are selected.

4. Chronos Visualisation System

We have developed a prototype interactive visualisation system, called Chronos, which implements a number techniques for supporting focused viewing and context awareness of scheduling data, as well as viewing hierarchical and other forms of relationships between tasks and sub-tasks. These techniques have been implemented for both Gantt and temporal mosaic visualisation methods, with the aim of demonstrating possible advantages of the mosaic visualisation over Gantt charts in relation to each of these methods, in an interactive visualisation context.

Figure 2 shows the interface of the Chronos visualisation tool. The top two windows show part of a schedule for a house renovation example case in temporal mosaic (left window) and Gantt chart (right window). The bottom two windows show the same schedule in its entirety in mosaic overview (left) and Gantt overview (right).

4.1. Zooming and overview

As mentioned in section 3, zooming in conjunction with some sort of overview is a commonly adopted approach to providing a detailed view of part of a visualisation. Chronos has a standard overview mode for each of its visualisation

4.2. Tasks hierarchy

Chronos provides support for a two-level tasks hierarchy\(^1\). In both mosaic and Gantt visualisations tasks can be folded and unfolded to show their sub-tasks. Figure 4 shows the Lounge task which has been unfolded to show its sub-tasks (Wiring, Carpet, Window, Cabinet, and Painting) in both visualisations.

Although the concept of zooming is the same in both types of visualisations, mosaic has one major advantage over Gantt in that mosaic uses the entire available space under any level of zooming. This is particularly important if the schedule contains many tasks. In that case, regardless of the number of tasks, mosaic zoom is only done horizontally (i.e. zooming in time), whereas Gantt needs to be zoomed both horizontally (i.e. zooming in time) as well as vertically (i.e. zooming in tasks space). This basically means that to find the right task at the right period of time users may need to scroll both horizontally and vertically in Gantt, while they only need to scroll horizontally in mosaic. Clearly, scrolling in two directions is more likely to cause the user to get lost within large schedules than scrolling in only one direction. Therefore, maintaining focus and context awareness is simpler in temporal mosaic than in Gantt charts.

\(^1\)In principle it is possible to have multilevel hierarchies, but this hasn’t been implemented in the current version of the system.
this problem becomes even more apparent when multiple tasks are unfolded (see Figure 5), where in the case of the temporal mosaic the shape of the visualisation remains the same and all the relevant sub-tasks are shown, while most of the required information is out of view in the Gantt chart.

4.3. Blurring out information

Chronos incorporates another useful functionality for viewing details of tasks while providing context awareness, by allowing the user to select a task (and its sub-tasks, if the task is unfolded) and blur out the other tasks and sub-tasks. Figure 6 shows the Lounge task and its sub-tasks selected, and all the other tasks (and their sub-tasks) blurred out. Once again, while this functionality is useful for both visualisations, temporal mosaic retains its overall shape and provides more context information particularly if the sub-tasks being selected are in different parts of a large schedule. For instance, compare Figure 7 with Figure 6 where a different set of sub-tasks (Bedroom sub-tasks) is selected in the same time period.

4.4. Tasks attributes and relationships

Although representation of task hierarchies is available in some interactive visualisation systems, representation of other task attributes and relationships is less common. Chronos provides a mechanism for defining and associating specific attributes to different tasks and sub-tasks, and then using those attributes as a way of showing relevant tasks while blurring out the other tasks in a manner described in the previous section.

If there is a need, for instance, to view all Carpet sub-tasks regardless of which tasks they come under, it is possible to define a common attribute (e.g. carpeting) for all of them, and then use that particular attribute to select the related sub-tasks. An example of this is shown in Figure 8. As with previous examples, mosaic shows all the selected sub-tasks within the viewing time period, while Gantt only shows whatever falls within the viewed time period and tasks space (e.g. in Figure 8 only the Lounge Carpet sub-task is viewable in the Gantt chart, while mosaic shows it for both Lounge and Bedroom).

4.5. Direct manipulation of schedules

Chronos also allows direct manipulation of tasks and sub-tasks in both visualisations, through a simple drag and drop operation. Once again this works better in mosaic, since for example, when dragging a task, represented by a contiguous region, along the timeline, the shape of that task region as well as its surrounding mosaic pattern changes progressively to reflect the changing constraints that the tentative re-allocation of the task would imply with respect to existing allocations. This implements a form of what-if analysis that preserves context awareness.

5. Conclusions

The design of Chronos has addressed several issues on scheduling and visualisation of complex tasks identified both in the literature and through our prior user studies. The proposed design builds on the space efficiency of temporal
mosaics, supports viewing of different levels of detail while maintaining awareness of context, and displays task hierarchies and attribute relationships in a natural way. Although the comparisons presented through Chronos’ visualisation of the two alternative representations indicate clear advantages of temporal mosaic over the Gantt-like representation, we intend to conduct a formal user evaluation of Chronos in order to compare the effectiveness of the two alternative visualisations in greater detail.

References