The role of objects in the coordination of knowledge-intensive projects: A study of computer games development

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Abstract
This paper addresses the role of objects in enabling the coordination of highly knowledge-intensive projects. An empirical study of project work in the computer games sector explored the role played by milestone schedules. We found that such objects played a central role in coordination in several related ways which could not be explained in terms of previous theorizing. First, such objects exhibited a capacity to act as a meta-object; i.e. representing and interrelating other objects. Second, through their narrative quality, these objects were critical to collaborating groups’ ability to respond to the emergent features of project work. Third, by representing the practices of different groups temporally, these objects made them more accountable to management control.

1. Introduction
This paper contributes to the ongoing debate on the role played by objects in the coordination of knowledge-intensive and innovative projects [1][2]. Such projects are seen as posing a challenge for conventional forms of coordination and management. The increasing prevalence of such projects, featuring unforeseen events, unpredictable dependencies and high pressure time schedules [3], is seen as requiring greater attention to the more dynamic organizing practices found in contemporary settings [4].

While a number of studies have highlighted the important role which ‘boundary objects’ may play in coordinating project work [1][2] other studies have questioned that role, suggesting that such objects may be less significant in organizational settings which are fast-changing, technologically intense and heterarchical. In a study of development projects within a web-based marketing firm for example, the researchers found that the coordination amongst groups did not revolve around the sharing of boundary objects but was secured through a set of work group practices which they termed ‘display’, ‘representation’ and ‘assembly’ [5]. Similarly, a study of virtual team collaboration in a project-based multinational organization [6] found that boundary objects, specifically project management tools such as timelines, had little value for the coordination of virtual teams as they were too readily discarded by some groups. The authors concluded that; ‘Boundary objects, because of their marginal nature, are prone to be relegated to the edge of projects’ (p. 1531).

In response to the uncertainty surrounding the coordinative role of objects, this paper aims to contribute to theory development through the analysis of an empirical study of new product development activities in the computer games sector. This sector represents a highly appropriate setting because computer games development represents an ‘extreme’ case in which relevant empirical phenomena can be fully explored. In particular, the work process here incorporates features identified as relevant by the conflicting perspectives outlined above; namely diverse forms of specialist expertise and a highly dynamic work process.

Through this study we sought to address the following research question: What is the role of objects in coordinating the work of specialist groups within the distinctive work process of computer games development?

2. The role of objects in coordinating knowledge-intensive work processes
In theorizing the coordinative challenges posed by knowledge-intensive projects, some writers have emphasized organizations’ dependence on a diverse array of expert groups. Coordination between these groups is seen as hampered by the difficulties of sharing knowledge, and of creating shared
understandings around tasks. As a result, 'coordination is less dependent on structural arrangements and more contingent on knowledge integration.' [7: p.1155].

This focus has highlighted the potential for certain objects to act as 'boundary objects' in supporting coordination between different expert groups. Such objects possess a boundary-spanning capacity due to their ability to 'inhabit several intersecting social worlds ... and satisfy the informational requirements of each of them' [8: p.393]. The concept was subsequently extended by Carlile [1] to encompass coordination across different functional groups in new product development activities.

In the wake of these theoretical developments, the boundary object concept became widely used to explain coordination amongst disparate groups [9] [2]. Despite its spread in the literature, however, the boundary object concept has been challenged by studies which see the coordination challenges of knowledge-intensive projects as centring less on knowledge boundaries than on features of the project and its organizational setting. Kellogg et al. [5] suggest that the speed of project work and increasingly 'heterarchical' forms of organization preclude the time-consuming investments needed to endow objects with a boundary-spanning capacity. They argue that coordination across groups can be achieved through work practices based on display, representation and assembly. By these means, organizational actors may 'juxtapose their diverse efforts into a provisional and emerging collage of loosely coupled contributions' (p.38).

One important implication of these findings is to highlight the speed of project work as a determinant of coordinative mechanisms. This suggests that the temporal dimension of such work, as much as the forms of specialized knowledge involved, may be a significant influence on the role played by objects. Most previous work has addressed this temporal dimension primarily as a contingent factor in the use of objects. Thus some studies have emphasised that only a limited number of objects achieve and sustain any boundary-crossing capacity over time [9]. Other studies have highlighted the temporally specific use of objects. Barrett and Oborn [10] for example, found that the boundary-crossing role played by project management tools varied during the course of a project. In the initial phase 'team members were able to negotiate collective meaning using the (software) spec and project management tools (e.g. timelines) as boundary objects' (p. 1210). In later phases, however, the 'plasticity' of the project management tools was reduced, and these objects actually became a barrier to knowledge sharing between groups.

Few studies, however, have addressed the way in which the temporal dynamics of projects – including the speed and life cycle of project work - are socially constructed through the use of objects. An exception here is Yakura’s [11] study of the use of timelines in managing projects. This study argues that the 'narrative' quality of such temporal boundary objects distinguishes them from other organizational artefacts. Because they allow participants to 'envision the ending of an otherwise open-ended story' (p. 956), they not only serve as a nexus for interpretation and negotiation, but also ‘promise an ending… to an inherently uncertain endeavour.' (p. 956).

3. Research design and methods

Our empirical study of computer games development was conducted between September 2008 and January 2010. The study involved fifteen separate visits to three games development companies in this period to investigate the way in which work was coordinated amongst different groups in the course of developing computer games products. The selection of the computer games sector fieldwork setting was based on its relevance to theory development on the role of objects (Eisenhardt 1989), reflecting and contributing to current debates. The computer games sector is a particularly relevant arena since it involves highly knowledge intensive work processes focussing on innovation and new product development. At the same time, computer games organizations embody the technologically intense and heterarchical characteristics highlighted in recent studies [5] [6]. Development processes are highly emergent and pose serious challenges for coordination, particularly in relation to the intangible dimensions of the computer games product [12].

The three organizations were chosen as appropriate sites for the study of organizing processes because they had evolved sophisticated
work processes and management practices, as reflected in their long-run records of success in a volatile and highly competitive sector. We therefore anticipated that they would provide insights into robust mechanisms of coordination within this sector. They were also organizations focussed on new product development, and encompassing a range of computer games users. While the size of computer games firms in terms of number of employees is generally closely linked to project life cycles, these three firms were all of similar size (around 250 employees). They have been labelled as follows (using pseudonyms to preserve company confidentiality): Quipp, PetName and Dredd. A summary description of each organization is as follows:

**Quipp:** Since its foundation in 1990, Quipp has grown into a leading independent multi-platform developer comprising five distinct divisions: family games; mature titles; serious games; downloadable games; and games technology. The company develops games under its own brands, as well as on behalf of external publishers and intellectual property rights holders.

**PetName:** Since its formation in 1997, this company has developed a series of commercially successful, critically-acclaimed, and award-winning strategy, action role-playing, and simulation games. The company develops its own titles, almost exclusively for the Xbox console, with dedicated teams moving from one release of the title to work on the next release in quick succession.

**Dredd:** Since its establishment in 1992 this company has grown significantly through the acquisition of other UK studios. The company produces games both under its own brand and for third-party clients, and has enjoyed significant commercial success. It is now a multi-platform and multi-genre developer operating out of four different locations around the UK.

While the inclusion of multiple sites helped to ensure that our findings were more deeply grounded in empirical evidence [13], variance across organizations was not a central focus of our study. Rather, we were particularly concerned in our data-gathering to locate the use of objects within an unfolding project work process. This concern reflected the studies described above which have highlighted the importance of the particular work process and context in which objects are situated, and also the shifting roles and functions of objects over time [10]. As outlined in previous work, such a focus involves the use of fieldwork methods, and entails ‘observing individuals in practice and focusing on the objects they work with and the ends that they pursue’ [1: p.446].

The primary sources of data included twenty five interviews, and 60 hours of observations. Informants for the interviews were selected to provide a cross-sectional view of the groups involved in the work process. Their roles thus ranged across different levels of management (development managers, commissioners, heads of design and programming), different functional groups (games engine, weapons, animations, and so on) and different levels of technical expertise (team leaders and team members). Interviews were conducted both in the formal settings of managerial offices, and, less formally, with informants in the games development workspace.

### Data analysis

The analysis of our data involved, first, the coding of our interview transcripts to identify key categories and themes [14]. The initial coding stage was followed by an analysis of the coded statements and involved the inductive exploration of themes that emerged from the data, and subsequent revision of these themes through our theoretical concern with the role of objects [15]. A particular focus in the coding of the data was to identify the interplay between and amongst developer groups and the work process, and the appearance and effects of different objects within that process over time. In addition, through a recursive process of refinement and comparison amongst the authors, we sought to relate the analysis of interview transcripts to the observational and documentary materials acquired from our fieldwork settings.

One important finding from these analyses was a high level of commonality (minor differences in terminology aside) in the structuring of the project work process across all three of the research sites, including the expert groups and practices involved, and the objects in play. In presenting the findings from our empirical study, therefore, we have chosen not to present materials on an organization by
organization basis. Instead, to foreground our theoretical concerns, we present our findings by drawing on data from all three fieldwork sites.

4. The process of computer games development

The development process in our research sites involved a variety of developer groups enacting work practices centred on, developing games which will be attractive to and engaging for users. In this process, an original idea or concept is progressively elaborated and translated into computer code that can be executed on a purpose-built console or on personal computers. Ultimately, for this code to run, what is called the ‘game engine’ – the software that interacts with the hardware of the target platform on which the game will be played (e.g. console, PC) – must translate the elements, or ‘assets’, that make up the game into the code that can be run by the different hardware components of the platform.

An overview of the work process in which these groups were engaged is provided in Table 1. It outlines details of the key informants for different phases, and the work practices making up the major elements of the development process, together with the objects and activities involved in coordinating and structuring the process over time. It is not intended, however, to reflect an exact chronological ordering of practices, activities and objects. We recognise that in presenting this view, we risk reifying games development as a linear process, hence neglecting the contingent and emergent aspects of practice. However, this approach does allow us to locate the role of objects within the wider process of project work. The particular coordinative functions of these objects and the links between them are described in further detail in Table 2.

5. The role of time-related objects and practices

Milestone review meetings

The key time-related practices observed in our study are performed within a specific arena, milestone review meetings. These take place at regular intervals, typically every five or six weeks. In addition to checking the delivery of outputs agreed for that period, they also provide a forum for a detailed ‘show and tell’ meeting of all project teams in which different teams make presentations on their previous and planned work activities. This helps to highlight interdependencies between the teams and also with the milestone schedule.

These meetings enable the collective viewing
by all the teams of the layout and features of existing locations and levels in the current build version of the game. This supports the alignment of their disparate work practices with the still emerging content, look and feel of the game, by enabling collective discussion of how particular features relate to the overall logic of the game or a particular playing experience. Once particular dependencies have been reviewed and agreed within the meeting, subsequent actions and resource commitments are specified, and changes made as necessary in the GDD and milestone schedule.

The format of the meeting practices, however, also enables coordination across groups to accommodate unplanned but necessary emergence. This can be illustrated by one of a number of episodes recorded in our field notes. In this meeting, the design team made a presentation to the other developer groups of a newly developed quest. This had implications for locations, and characters within the game, and other objects including the art and technical design documents.

In their presentation, the team members began by relating the quest to the game's narrative. In this part of the narrative, the hero visits a 'gypsy' village to meet the gypsy king and his son and other characters there. There the king sets him a task to confront the 'renegades'; a band of marauding ex-soldiers who have turned to banditry after being decommissioned from the army. Discussion of the quest quickly turned from technical aspects of the 'deliverables' to focus on more existential questions to do with its logic and purpose. For example, several developers from other teams asked why the 'renegades' should fight the hero by default and proposed other possibilities for the hero's actions. Further discussion in the meeting explored the implications of different actions for player choices, character development and game outcomes.

In response to this discussion, the design team’s leader conceded that the quest was ‘unsatisfactory’ and needed further development, with consequent ramifications for other parts of the process. At the same time, he also highlighted certain constraints on the scope of any re-design. These included the constraints posed by the evolved logic of the entire game, and the need to relate any further changes to assets already installed in the build version of the game. Instead, he proposed that the design team should explore a more modest ‘tweaking’ of the stage/quest. If this could not produce a satisfactory reworking of the quest, he indicated that it might be necessary to abandon it rather than commit further resources.

The conclusion of the discussion was that the new quest would be held back for further review. As it had failed to secure approval for sign-off, its status in the build version was undecided. Meeting participants recognised the implications of this deferred decision for other objects, and particularly the need to revise the milestone schedule accordingly. The revision would be in place until the next milestone meeting in six weeks time when a decision would be taken on whether to persevere with or abandon the quest.

The role of the milestone schedule

The need to accommodate the above-noted emergent features of project work clearly limited the use of conventional project management tools in our case firms. Thus, Dredd used MS Project only for more routine projects, while the other sites had abandoned any attempt to use established commercial project management software. This was partly on the grounds that it was too inflexible in responding to emergence, but also because it lacked the boundary-spanning capacity of more widely used and understood tools such as Microsoft Excel. Developers at Quipp also used specialist project management software application which had been designed specifically for games development.

While more specialist tools were applied within the project management group only, the most widely shared time-related object in our study was the milestone schedule. This typically took the form of a large tabular matrix which related the High Level Goals of the project to key work areas such as ‘Engine’, ‘Gameplay’, ‘Characters & Creatures’, and ‘Regions’. Within the document these areas are subdivided into smaller tasks and outputs, which are allocated to individuals and teams along with specific time allocations. Every milestone specified for the game’s development would be accompanied by such a schedule, covering the timeframe between review meetings.

One of the central roles of the milestone schedule is to associate the game, art, and technical design documents to the temporal
ordering of the work process by scheduling all the deliverables specified in those documents. It is through the resulting ordering of the ‘assets’ specified and relationally ordered in the design, art, and technical documents that many problematic dependencies are surfaced. This is illustrated by the following observation from a development manager at PetName:

‘We’ve had problems with dependencies. Say the scripters who are implementing the story and the quest, saying: ‘we need this character—oh, but that character is not ready’. The art animation, therefore, was not ready, and with the script, they hadn’t had enough time to put into their script for that milestone.’

The milestone schedule also drew on other objects to specify how different deliverables would be produced. For example, incorporating details from the studio’s staff plan allowed particular individuals or groups to be charged with developing a certain feature. Explaining the link between the staff plan and the milestone schedule a development manager at PetName explained;

‘We have a staff plan. We know who’s available from when to where. We work out the costs, we know the dates; we work out when we want it to be in the street, and we work backwards from that. We fiddle with the numbers and make sure we have the right number of people and have a plan for when we can recruit them and what kind they are going to be.’

As highlighted by Table 2, the milestone schedule was also linked to the timeline and budget for the game as initially outlined in the concept document and usually formalised through some kind of project agreement or contract. The links outlined in the Table are one important instance of the wider set of relations and interdependencies which helped to ensure that any changes made in one object were speedily relayed to the others, thus preserving stability in the coordination of work activities even in the face of emergent conditions.

6. Discussion and Conclusions

As we noted at the outset, the games development process poses severe challenges for coordination. Developer teams need to develop a nebulous initial concept into a fully realized artefact capable of immersing users in new aesthetic and sensory environments. The range of expertise required to do this is extremely broad. However, the challenge for coordination is not only to achieve the alignment of practices and sharing of knowledge amongst these different specialist groups, but also to do this within a defined timeframe and body of resources.

Our analysis highlighted the centrality of time-related objects and practices to supporting coordination under conditions of emergence. In particular, we found that the milestone schedule performed as a ‘meta-object’ in coordinative terms, inasmuch as it incorporated a capacity to represent other objects and changes in the dependencies between them. That capacity is illustrated by our account of the milestone review meeting and the way in which the emergence resulting from the changes to a quest was represented through changes in the milestone schedule, and hence altering the status of linked objects. As Yakura notes in her study; ‘Unlike other boundary objects which remain relatively stable over time, a timeline changes with each passing day’ (p. 968).

This episode, together with evidence from our interviews and observations, underlined how the implication of changes in one area of product design could be quickly relayed via changes in linked objects in use such as the concept book, GDD, and the milestone schedule across the work process as a whole. The milestone schedule thus not only supported coordination between the practices of different groups, but also helped to ensure that their practices were advanced within a time-bounded work process. As a result, representation of the technical dependencies amongst product features could be narratively enmeshed with the process dependencies of time and financial resources. This had the effect of representing the practices of the different developer groups in a form which was more amenable to management control and accountability.

The role played by the milestone schedule and related practices in our study has not been addressed in previous work, which has tended to focus on the coordinative capacities of discrete and not related objects. In highlighting this contribution to theory, however, we need to acknowledge that
computer games development is a distinctive setting for the study of coordination. As with previous work on this topic, the specificity of the setting inevitably places limitations on the generalizability of our findings. At the same, qualitative research in this setting is justified as appropriate to theoretical development on the role of objects in coordinating knowledge-intensive work. The need for further theorization here has been highlighted in the recent period by studies criticising the boundary object concept.

Through our empirical focus, we were able to identify the differing capacities provided by objects such as the milestone schedule when embedded in the practices of developer and managerial groups. In addition, however, our focus on the work process as a whole showed that it was not only these objects but the relations between them that were embedded in work practices, and that these relations played an important coordinative role in their own right. These links afforded greater centrality to certain objects, such as the milestone schedule, which were able to represent and inter-relate other objects. As a result, their use not only referenced the practices of different groups with each other, but also located such practices within the temporal and resource constraints of the wider work process.

The contributions outlined above suggest that a valuable focus for further research in this field would include greater attention to variations in the temporal dimension of project work and how they influence the coordinative role played by objects. Also, while our study highlighted several aspects of the narrative and temporal role of inter-object relations in coordination, this represents an initial finding requiring further examination. This might include, for instance, the processes through which relations amongst objects are established in the practices of diverse groups, and a more detailed investigation of its implications for the exercise of managerial control over unpredictable development processes and relatively autonomous work groups.

7. References

Table 1: The work process of computer games development: Practices, objects and coordination

<table>
<thead>
<tr>
<th>Planning &amp; production activities</th>
<th>Key objects in use</th>
<th>Work practices</th>
<th>Groups involved</th>
<th>Fieldwork key informants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-approval</td>
<td>Concept book</td>
<td>Game concept development</td>
<td>Game designers, team leads (art, design, programming), business development specialists, internal/external game commissioners</td>
<td>Director of development, Director of business development, Head of Franchise, Development manager, Commissioner, Head of Design, Head of Art, Head of production, Editorial production; R&amp;D Manager</td>
</tr>
<tr>
<td>Green-lighting (Project approval)</td>
<td>Concept book, Project agreement</td>
<td>Project negotiations</td>
<td>Senior executives, team leads, commissioners, legal specialists, production management, finance specialists</td>
<td>Director of development, Director of business development, Head of Franchise, Development manager, Commissioner, Head of production</td>
</tr>
<tr>
<td>Specification and scheduling activities</td>
<td>Milestone schedule, Game design document, Project agreement</td>
<td>Development and sequencing of detailed game specifications</td>
<td>Production tasks, Drawing tasks, character action, building locations and quests</td>
<td>Director of development, Head of Franchise, Development manager, Commissioner, Head of production</td>
</tr>
<tr>
<td>Milestone review meetings</td>
<td>Milestone schedule, Game design document</td>
<td>Production tasks, Drawing tasks, character action, building locations and quests</td>
<td>Asset pipeline management</td>
<td>Director of development, Head of Franchise, Development manager, Head of production; Head of programming, Head of Design, Head of Art; Chief of design production; Programming production coordinator; Game editor support; Physics engine developer; Weapons &amp; message box programmer; Weapons artist; Physics engine engineering manager</td>
</tr>
</tbody>
</table>
Table 2: Shared objects used to coordinate games development

<table>
<thead>
<tr>
<th>Object</th>
<th>Description</th>
<th>Role in Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept book/document</td>
<td>Provides the developers and other stakeholders with an overview of the characters, locations, and relations of characters to each other, to the game world, and the logical unfolding of the game.</td>
<td>Coordinates the work of the developers involved in assembling more formal descriptions of the assets that need to be created and brought together in the GDD, TDD, ADD</td>
</tr>
<tr>
<td>Game design document (GDD)</td>
<td>Provides developers with a detailed inventory of all the elements of the game and the distribution of these in the space of the game world. Locations are described using a standard format with document sections that are common to all locations across the game. Quests or tasks are also formally described in a standard format that is common across the game.</td>
<td>Coordinates the work of the developers by specifying through these formal descriptions the assets that have to be developed, how these assets relate to the overall game, and also formal properties for 'assets' they have been assigned to produce.</td>
</tr>
<tr>
<td>Technical design document (TDD)</td>
<td>Outlines how the game as described in the GDD will be implemented in terms of programming requirements and limitations.</td>
<td>Coordinates the work of the developers as a whole by presenting to them key considerations such as the polygon count and CPU and memory budgets for each scene found in the GDD. Also coordinates the work of the programmers by specifying changes to software applications, the technical organisation of the production process, and the 'game engine' in order for a particular outcome to be possible.</td>
</tr>
<tr>
<td>Art design document (ADD)</td>
<td>Provides high level art concepts and specific detail and style definitions for individual assets, locations, and scenes and information on digital art tools that will be used in the development process and final delivery specifications.</td>
<td>Coordinates asset development through the construction specifications for assets such as, the number of bones in a body, the scale, orientation, and measurement units to be used in the 3D art package used, or the data formats to be used for 3D and 2D digital art assets. Coordination in terms of workflow is also provided by specifying locations from which any required in-house and third party plug-ins can be gathered.</td>
</tr>
<tr>
<td>Milestone schedule</td>
<td>Draws on the GDD and related documents and staff plans in order to link deliverables to individuals and teams over time. It is also through this schedule that the performance of individuals, teams, and ultimately the company itself are judged, evaluated and rewarded, with payments from clients or internal commissioning entities tied to the attainment of milestones.</td>
<td>Provides the temporal coordination of the game development project, ensuring that the development and delivery of assets and other inputs follows the required sequence.</td>
</tr>
</tbody>
</table>