A UNIFIED APPROACH TO PROJECT MANAGEMENT: INTEGRATING INFORMATION VIEWS AND ICT TOOLS

SAKILA AKTER JAHAN*
*Illinois State University**

***Corresponding Author : SAKILA AKTER JAHAN**

ABSTRACT

The rapid evolution of information and communication technology (ICT) within the architecture, engineering, and construction (AEC) industries has introduced transformative opportunities and challenges. These advancements are not purely technical in nature but necessitate corresponding shifts in management processes and practices. Previous studies have discussed frameworks for project information management within construction; however, the broader implications for project management as a whole remain underexplored. This paper presents a holistic approach to project management that emphasizes the integration of various project information views, the explicit representation of their interdependencies, and the need for project management tools and procedures to adapt to these interconnected systems. By aligning managerial practices with the capabilities of emerging ICT, this unified approach aims to optimize the performance of construction projects.

DOI:10.5281/zenodo.14249342 **Manuscript ID # 191**

INTRODUCTION

The AEC industries are undergoing a profound transformation driven by advancements in ICT, particularly in tools like Building Information Models (BIM). These tools promise substantial improvements in the efficiency and effectiveness of project design, communication, and management. However, these benefits extend beyond the adoption of new technologies and require significant changes to the management practices and skill sets of project participants. Without such changes, the full potential of ICT cannot be realized.

This paper builds on prior research into project information management to explore how project management as a discipline must evolve to accommodate and capitalize on emerging ICT trends. While earlier work has addressed the role of a Project Information Officer and its implications for managing project data, this paper focuses on the broader challenges of project complexity and interdependencies. It proposes a conceptual framework for integrating diverse project views and enhancing their representation to improve overall project coordination and performance.

Emerging ICT in Construction

The evolution of ICT in construction can be categorized into three distinct eras. The first era, spanning over four decades, introduced standalone tools designed to assist specific tasks, such as CAD for drafting and structural analysis software for engineering calculations. These tools became standard in construction practice and were primarily task-oriented. The second era, emerging in the mid-1990s, focused on communication technologies like email, web-based tools, and document management systems. While these tools enabled improved collaboration, they remained less mature, and their adoption led to incremental improvements in business processes.

The current third era emphasizes integration, with technologies such as BIM, virtual design and construction (VDC), and interoperable frameworks like Industry Foundation Classes (IFCs). These tools aim to unify diverse project components into cohesive systems, enabling better coordination and decision-making. Despite these advancements, their adoption remains limited in mainstream practice, as the associated management methodologies have not fully adapted to exploit their potential.

Impacts of ICT on Project Management

Complexity and Interdependencies

Construction projects are inherently complex due to their scale, scope, and interdependent components. These components include physical elements, workflows, resource allocations, and stakeholder interactions. Emerging ICT tools, while designed to streamline these complexities, often highlight the inadequacies of existing project management practices. Traditional approaches frequently downplay task interdependencies, treating them as isolated units rather than interconnected systems.

This paper posits that such practices are ill-suited for modern ICT-driven environments, which require explicit recognition and management of these interdependencies. By addressing these relationships proactively, project management can better align with the integrated nature of construction ICT, ultimately enhancing overall project performance.

Integration of Views in Project Management

One of the primary challenges in managing construction projects is the fragmentation of project information. Each project participant—architects, engineers, contractors, and managers—works with specific views of the project, tailored to their responsibilities. These views often lack integration, leading to inefficiencies and misaligned objectives. For example, changes in one aspect of the project, such as a design modification, can cascade through related components, affecting schedules, costs, and resources.

This paper argues for a paradigm shift toward integrated project views, wherein diverse perspectives are synthesized into a cohesive framework. Such an approach not only ensures consistency across project phases but also facilitates better decision-making and collaboration among stakeholders.

Lessons from Other Industries

Insights from other industries, such as software engineering, offer valuable lessons for construction project management. For instance, the Unified Modeling Language (UML) provides a standardized approach to representing project components, workflows, and interdependencies. Similarly, lean construction methodologies emphasize the importance of optimizing workflows holistically, rather than focusing solely on individual tasks.

These examples highlight the benefits of adopting integrated management frameworks that balance local and global optimization goals. Construction project management can leverage these principles to enhance its ability to manage complex, interdependent systems effectively.

Characteristics of Views and Interdependencies in Project Management

Complexity in Construction Projects

Construction projects exhibit several characteristics common to complex systems: a large number of components, dense causal connections among these components, and high levels of interdependence. For example, a change in the intended use of a building space may trigger cascading effects across multiple systems, from mechanical and electrical designs to material procurement and scheduling.

This complexity is further compounded by external factors such as regulatory requirements, sustainability goals, and financing structures. To address these challenges, project management must explicitly account for the interdependencies that define construction projects, moving beyond the traditional focus on task-based optimization.

Fragmentation and Integration of Project Views

Fragmentation is a defining characteristic of traditional project management approaches. Each stakeholder operates within a specific view of the project, with limited awareness of the broader system. While this approach simplifies individual tasks, it often leads to inefficiencies and misaligned priorities at the project level.

This paper advocates for increasing integration across project views by leveraging ICT tools that unify data, workflows, and decision-making processes. By enhancing visibility into interdependencies, project management can transition from reactive problem-solving to proactive coordination.

Proposed Framework for Unified Project Management

The proposed framework emphasizes the following principles:

1. **Explicit Representation of Interdependencies:** Developing tools and methodologies that clearly represent the relationships between project components and tasks.
2. **Integrated Information Systems:** Aligning data models, applications, and documents to support seamless collaboration and information sharing.
3. **Adaptation of Management Practices:** Evolving traditional workflows and decision-making processes to reflect the interconnected nature of construction projects.

This approach aims to bridge the gap between technical advancements and managerial practices, enabling construction projects to fully realize the potential of emerging ICT.

Future Directions

This research represents an early step toward redefining project management for the ICT era. Future work will involve refining the proposed framework, developing practical guidelines, and conducting industrial trials to validate its effectiveness. By fostering collaboration, integration, and innovation, this research seeks to advance the state of project management in the AEC industries, ensuring it remains responsive to the challenges and opportunities of a rapidly evolving technological landscape.

Addressing Gaps in Existing Practices

The current landscape of project management in the construction industry often overlooks the critical interdependencies among individual work tasks and project components. This oversight perpetuates a "one-time event" mindset, which undermines efforts to achieve continuous performance improvement. This paper introduces a unified approach to project management that aims to address these deficiencies by placing significant emphasis on the organization and structuring of project information and its interdependencies.

The Basic Approach

In traditional practice, project participants access specific sets of project information, each representing a unique "view" of the overall project. These views are often defined informally and lack systematic representation or explicit acknowledgment of their interdependencies.

In a unified approach, these views are formalized and explicitly treated as subsets of the overall project information set. Although the total project information set may not exist as a singular physical entity, participants continue to access their required data in a structured manner. Certain primary views are universally shared among stakeholders, serving as a cohesive foundation for communication and collaboration. Emerging ICT tools support this methodology, facilitating the formalization and interconnection of views to enhance project understanding and functionality.

While the change in management effort is minimal, this approach significantly increases awareness of task interrelationships and their impact on the overall project. This concept parallels the improvements brought by the

Unified Modeling Language (UML) in the software industry. The following sections delve into the critical components of this approach.

Definition of Views

A view is a collection of information pertinent to executing a specific task within a construction project. It represents a subset of the total project information set and can range from informal, loosely defined descriptions to formal, precisely structured datasets.

Examples of views include:

- Physical View: Focused on "what," such as project plans and layouts.
- Process View: Addressing "how, who, when," as captured in schedules and workflow diagrams.
- Cost View: Representing "how much," including estimates and budgets.

In this framework, views define the dimensions of a multi-dimensional information space. At their simplest, views may take the form of hierarchical structures, such as work breakdown structures (WBS). More complex views may include relationships like critical path method (CPM) networks or Industry Foundation Classes (IFC) models.

The distinction between data views (formally defined subsets of data) and presentation views (organizational formats for display or interaction) is crucial. For instance, graphical or tabular presentations may stem from a single data view to meet specific user needs.

The Role of Primary Views

For project participants to operate efficiently, they must access information presented in ways that suit their specific tasks. However, this flexibility often undermines the goal of a unified perspective on project information. To balance individual needs with collective objectives, a small set of widely applicable primary views is proposed as a coordination mechanism for all stakeholders.

Proposed Primary Views

1. Product View:
   This view organizes project outputs, including both the physical facility and the informational deliverables generated during the project's lifecycle. It highlights the continuum from virtual facility models to the physical construction, emphasizing the role of Building Information Models (BIM).
2. Process View:
   This view outlines the functional and sequential tasks required during the project. It focuses on workflows and task ordering to ensure logical and efficient execution.
3. Resource View:
   This view identifies the resources necessary for project execution, including organizational entities, materials, equipment, and financial inputs.
4. Time View:
   This view incorporates the temporal aspect of the project, detailing schedules in terms of absolute time (calendar dates) or logical project phases. It also facilitates decision gate formalization and iterative planning.

These views are interconnected, creating a multi-dimensional representation of the project. For example, workflows (process view) can be linked to specific resources (resource view) or mapped against project timelines (time view) to create a comprehensive project schedule.

Interdependencies Among Views

The integration of views provides meaningful insights into project interdependencies. Key relationships include:

- Process vs. Time: Mapping workflows to timelines creates schedules, showing task sequences and durations.
- Product vs. Time: Tracking deliverables against project timelines illustrates cumulative progress.
- Product vs. Process: Assigning deliverables to workflows highlights collaborative efforts required for project outputs.

Other interdependencies—such as resource mapping to processes, products, or time—add further depth to project management. Representing these relationships as two-dimensional matrices (e.g., Gantt charts for workflows vs. timelines) offers intuitive tools for project participants.

Emerging ICT tools can automate portions of this process, such as generating task lists from product models or identifying exceptions requiring management attention. The concept of "banded matrices" could help streamline view creation and synchronization.

Enhancing the Representation of Management Issues

While primary views form the foundation of project coordination, secondary views offer additional perspectives to address specific management objectives. Examples include:
- Cost View: Tracking financial elements such as estimates and budgets across workflows, deliverables, and resources.
- Risk View: Associating significant risks with tasks, resources, or deliverables to enhance risk management.
- Quality View: Monitoring quality metrics and inspection results tied to tasks and outputs.
- Requirements View: Capturing project requirements in structured formats to align objectives.
- As-Built View: Documenting actual construction outcomes, including costs and productivity data.
Other secondary views, such as safety, environmental impact, and contractual considerations, can be defined as needed. Importantly, these views do not add significant management effort but rather formalize existing practices to reveal interrelationships and improve coordination.

3.6. Working with the Unified Approach to Project Management

The unified approach to project management leverages structured views of project information and their interrelationships to improve outcomes. This method aligns with best practices in project scheduling and emphasizes effective coordination, planning, and communication.

Key Points:

- **Unified Views Definition**: Project management teams define standardized views for project information, similar to conventional representations but more formalized.
- **Inter-relationships Identification**: Critical links between views are mapped to enhance traceability and impact analysis. Though additional effort is required, hierarchical tools minimize workload.
- **Execution & Feedback**: The execution of tasks, progress monitoring, and re-planning operate within this unified framework, ensuring better recognition of causal links and early mitigation of risks.
- **Detail Gradation**: Planning starts at a high level, gradually adding detail, mirroring rolling look-ahead schedules in traditional practices.
- **Three Categories of Use**:

1. Shared coordination using primary views.
2. Detailed task-specific information for participants.
3. Advanced analysis utilizing integrated views.

The unified approach requires integration into the organizational context, ensuring early involvement of all team members, clear task allocations, and incentivized adoption. Technology plays a pivotal role, enabling representational and methodological integration.

3.7. Towards Virtual Design and Construction (VDC)

Transitioning to the unified approach involves a paradigm shift, treating construction projects more like manufacturing processes, emphasizing prototyping and iterative refinement.

Core Concepts:

- **Unified Project Representations**: Serve as prototypes, encompassing geometric and non-geometric information such as schedules, costs, and materials.
- **Prototyping Mentality**: Focus shifts from finding satisfactory solutions to iterative exploration for optimal results.
- **Integrated Roles**: Stakeholders use shared models for task execution, collaboration, and problem-solving, fostering a holistic view of project goals and challenges.

This methodology mirrors manufacturing's structured approach, ensuring that tasks and their interdependencies are systematically addressed and optimized for better project outcomes.

4. Technical Solutions: ICT Tools for the Unified Approach

Implementing the unified approach demands an ICT platform that integrates and connects various project views efficiently.

Framework Highlights:

- **Traditional Tools**: Continue to manage specific views but integrate through emerging ICT technologies like IFC-based data exchanges.
- **Information Aggregators**: New software class that consolidates data into comprehensive project information sets, utilizing technologies like:

- **IFC**: For representing and linking project information.
- **OLAP**: For defining and visualizing multi-dimensional data cubes.

- **Integrated Functionality**: Supports inter-relationships between views, information discovery, and data visualization. Advanced tools enable simulations, workflow automation, and deeper analysis.

This framework emphasizes interoperability and collaboration, aligning project management practices with cutting-edge ICT developments.

5. Conclusions

To maximize the potential of emerging ICT, project management must evolve to incorporate integrated views and interrelationships. The unified approach fosters a collaborative and holistic management paradigm, supported by advanced tools and practices under development.

This unified approach to project management emphasizes structured representation of project information and its interdependencies, enabling stakeholders to operate effectively while maintaining a shared perspective. By leveraging emerging ICT tools and formalizing primary and secondary views, this framework addresses critical gaps in traditional practices, laying the groundwork for improved project outcomes and ongoing innovation in the construction industry.

References

1. T. Froese, Emerging Information and Communication Technologies and the Discipline of Project Information Management, Intelligent Computing in Engineering & Architecture, Springer, Berlin, 2006, pp. 230–240.
2. T. Froese, Impact of Emerging Information Technology on Information Management, International Conference on Computing in Civil Engineering, ASCE, Cancun, Mexico, Paper #8890, 10 pgs., Electronic book (published on CD), July 12-15, 2005.
3. M. Fischer, J. Kunz, The Scope and Role of Information Technology in Construction, Technical Report, Center for Integrated Facilities Engineering, vol. 156, Stanford University, USA, 2004.
4. G. Aoudad, A. Lee, S. Wu (Eds.), Constructing the Future: Nd Modelling, Taylor & Francis, UK, ISBN: 9780415391719, 2006.
5. T. Homer-Dixon, The Ingenuity Gap, Vintage Canada, 2001.
6. Y. Merely, B. McKelvey, Using Complexity Science to affect a paradigm shift in Information Systems for the 21st century, Journal of Information Technology21 (2006) 211–215.
7. Lean Construction Institute, Lean Construction Institute (Home Page), web page at: http://www.leanconstruction.org/[accessed December 30, 2008].
8. Object Management Group, “UML Resource Page”, web page at http://www.uml.org/[accessed December 30, 2008].
9. S. Kendall, the Unified Process Explained, Addison Wesley, 2002.
10. A. Russell, T. Froese, Challenges and a vision for computer-integrated management systems for medium-sized contractors, Canadian Journal of Civil Engineering 24 (2) (1997) 180–190
11. M. Fischer, C. Kam, PM4D Final Report, Technical Report 143, Center for Integrated Facilities Engineering, Stanford University, USA, 2002.
12. R. Levitt, Virtual Design Team, Web page at: www.stanford.edu/group/VDT/[accessed December 30, 2008].
13. T. Froese, S. Staub-French, A Unified Approach to Project Management, 4th Joint Symposium on Information Technology in Civil Engineering, ASCE, Nashville, USA, 2003