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Chronological Models (cMod)

Towards consistent lifecycle information management

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Lifecycle information management, OCCP, model chronology, ontology

1. INTRODUCTION

Effective temporal data management is a pressing challenge in construction projects, where accurate tracking of progress, changes and state transitions is essential. While BIM provides a strong foundation for data interoperability, it lacks tools to manage chronological information with precision. Filling this gap, Chronological Models (cMod) (Vaatz, A., et al., 2023) enable detailed time management by integrating timestamps, phase-specific data and lifecycle tracking to enable a Total Life Cycle Process (TLCP) (Wolf, G., et al., 2024) directly into BIM workflows.

The cMod Manager (cMM) acts as a central tool that connects IFC models to semantic temporal frameworks. It enables real-time validation, advanced querying and granular documentation of construction progress. This paper explores the concept of cMod and shows how cMM operationalises temporal management to increase transparency and efficiency in construction workflows.

2. CORE CONCEPT OF CMOD

Chronological Models aim to bridge the gap between static BIM data and the dynamic temporal needs of lifecycle information management (LIM). At its core, cMod provides a framework for embedding temporal information directly into construction models, enabling changes and progress to be tracked throughout the project lifecycle. Central to cMod is the ability to store, validate and visualise temporal data such as timestamps, phase transitions and historical states of components.

The cMod approach is based on three key pillars: temporal enrichment of IFC models, integration with semantic frameworks, and advanced data validation. By enriching IFC models with time stamps and linking them to semantic data structures, cMod ensures chronological consistency while maintaining compatibility with industry standards and concepts like applying ontology-based rules for infrastructure planning (Wogan, M., et al., 2024), (Mellenthin Filardo, M., et al., 2024) or other ontologies, such as the Damage Topology Ontology (DOT) (Hamdan, A.-H., et al., 2021). It supports a variety of use cases, including progress monitoring, phase-specific comparisons and detailed audits of planned versus actual timelines.

2.1 Main elements

The cMod concept revolves around three key modules that together provide a comprehensive framework for managing and validating time data in construction projects:

1. OCCP: The Ontology for Chronological Construction Processes (OCCP) serves as the semantic foundation for the lifecycle-based chronology. It provides the underlying structure for defining phases, transitions, cycles and events, allowing a flexible and ontology-driven approach to temporal data management. OCCP ensures logical consistency and a structured representation of the timeline, which is the basis for all cMod-related processes.

2. Model specific OCCP (MsOCCP): The MsOCCP is an IFC model-specific dataset in Turtle format that semantically structures temporal information. By enriching IFC components with temporal properties defined by OCCP, MsOCCP captures the chronology of building components. This dataset enables advanced queries, temporal validation and seamless integration of planned and actual data, bridging the gap between static IFC models and dynamic project schedules.

3. cMod Manager (cMM): The cMod Manager is a dedicated software application for creating, managing and validating cMods. It acts as an interface between IFC models, MsOCCP datasets and the user, providing tools to visualise, edit and ensure the consistency of temporal data. The cMM streamlines the handling of complex construction timelines, making them accessible and manageable within a user-friendly framework.

2.2 Components of the cMod Manager

The cMM is the operational core of the cMod framework and facilitates the integration, management and validation of temporal data. Its functionality is centred on several main components that ensure seamless data processing and validation:

1. IFC integration: The cMM imports IFC models to extract structural and property information. These models serve as the basis for associating temporal data, allowing the enrichment of structural elements with MsOCCP properties.

2. OCCP-based validation: Using OCCP as the semantic backbone, the cMM validates MsOCCP records against SHACL-defined rules. This ensures logical consistency within the temporal structure and verifies compliance with lifecycle definitions.

3. MsOCCP Management: The cMM provides tools for creating, editing and visualising MsOCCP records. It allows users to add new timestamps, define transitions and validate changes in real time.

4. Hash-based change tracking: To maintain data integrity, the cMM includes a hash-based change tracking mechanism for IFC models. This approach detects changes, additions or deletions to components, ensuring a consistent link between the IFC model and its associated MsOCCP data.

5. Git integration: The cMM integrates with Git for advanced version control. This allows users to maintain a detailed history of changes, branch management and collaboration. Every change in the cMM is committed to a Git repository, ensuring traceability and the ability to revert to previous states.

6. Information flow: The cMM facilitates a streamlined data exchange process. IFC models are loaded and linked to MsOCCP records, validated against OCCP rules and enriched with time information. Any changes are versioned using Git, with hash values ensuring consistency across all data layers.

By combining semantic reasoning, validation mechanisms and robust versioning, the cMM provides a practical solution for managing complex chronological, model-related data in construction workflows.

3. CONCLUSION

Chronological Models offer a transformative approach to time management in construction projects, addressing critical limitations in traditional BIM workflows. Combining semantic data integration, real-time validation and advanced visualisation, cMod enables accurate tracking of construction progress and status. The cMod Manager serves as the cornerstone, operationalising the concept and facilitating its integration into practical workflows. This paper highlights the potential of cMod to improve transparency, efficiency, data consistency and accountability in construction management, and lays the foundation for future advances in temporal data integration and building information management.

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