Multilayer Networks in AEC Building Information Modeling on Construction Projects

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THE DISRUPTIVE
DESIGN PRACTICE HANDBOOK

ARCHITECTURE

3.0

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Multilayer Networks in AEC BIM on Construction Projects

- Building Information Modeling (BIM) is a 3D digital process containing data regarding shared data regarding the project.

- Problem with shared *flawed* BIM data which propagates exponentially creating costly errors that are difficult to find and mitigate.

- Multilayer network theory enables the examination of the interaction between the separate layers of closed networks.

- We used Rumor Models to map flawed information to understand how to quarantine and mitigate incorrect BIM information.

Construction Projects Sample

- The design and construction industry generates 13% of global GDP -

- And has an estimated global value of $10.5 trillion -

- Productivity in the other sectors has grown by 500% since 1945, while output in the construction industry has increased by less than 2% -

- 80% of large projects experience cost overruns of 30% and schedule delays of 40%.

- Our research focuses on large ($1B+ US Dollars), multi-year, California Healthcare projects.

- Design teams create and share their BIM files with construction teams.

The Construction Project as a Complex System

- System of Systems.
- Many dynamically interacting agents and open systems.
- Elements within each system react only to information available within their individual systems.
- Each individual system has a history and agent churn.
- Social dependence/feedback loops reinforced through interaction and behavior.

Multilayer Networks

- Multilayer network theory identifies interconnected networks and systems.

- Study complex and dynamic interlinked organizational systems such as transportation and financial systems.

- Studied as a source of cascading exponential failures, increasing systemic risk.

- In AEC projects, systems can react to random failures different than mono-plex networks.
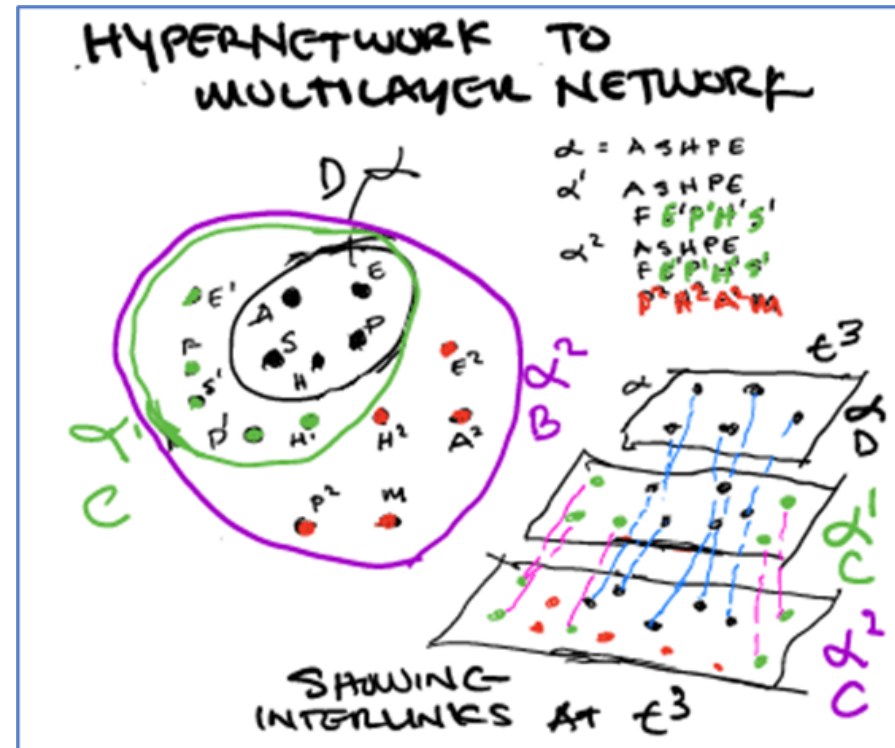
Construction Phase Mono-Networks
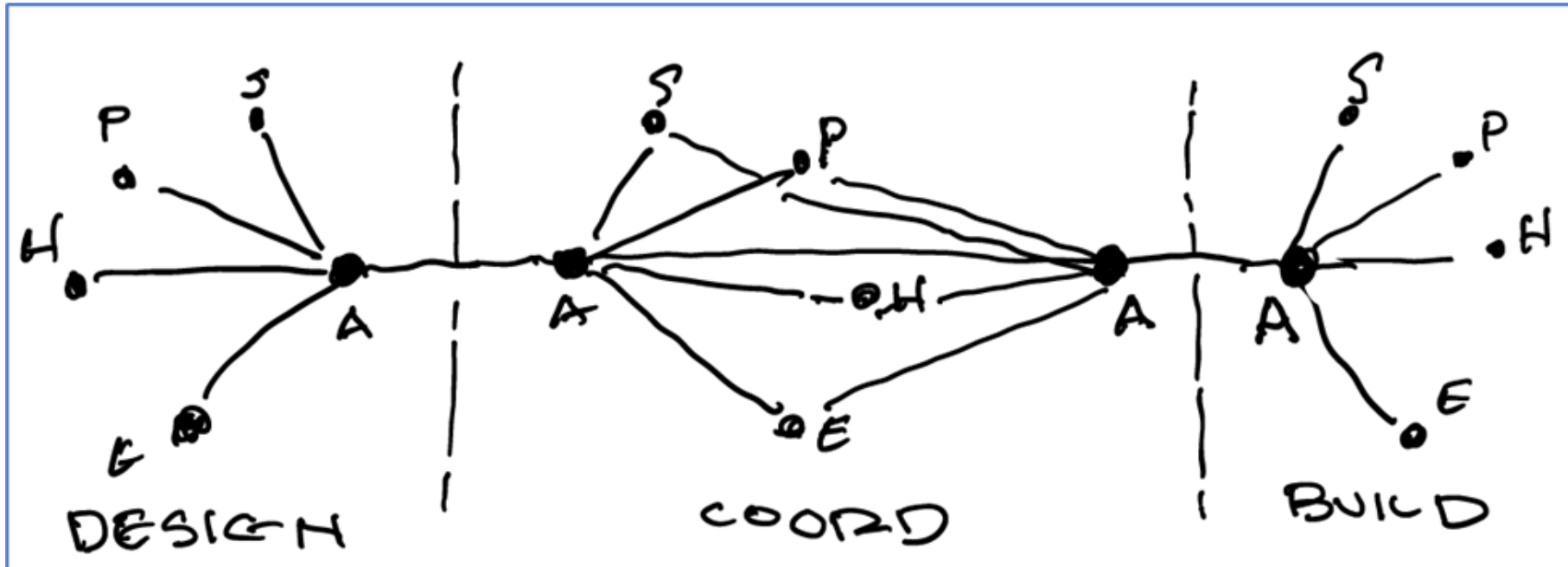
Architect Centric.
This graphic shows the time sequence as each modeling team performs and shares/links its individual models through the architect.
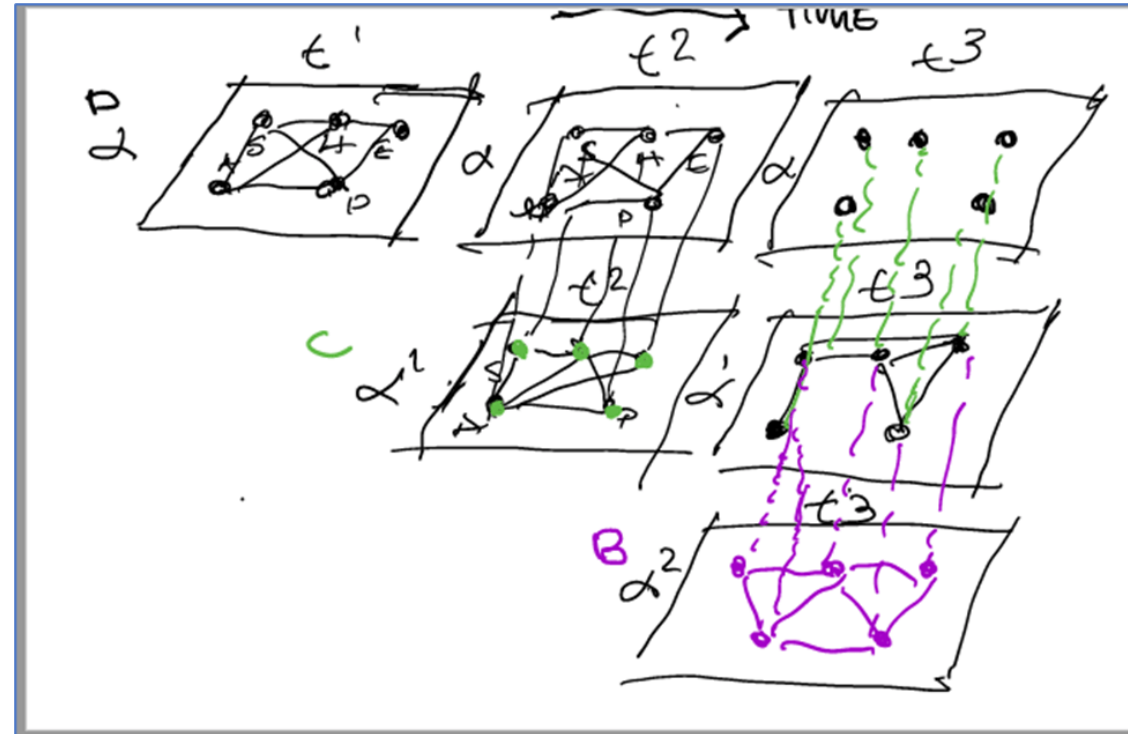Design to Coordination, Coordination to Build.
During Build, the models are released to the individual trades for construction.

# Hypernetwork to Multilayer Network

This graphic shows both the different Design and Coordination *hypernetworks* nested within the larger Build *hypernetwork,* and the Design, Coordination and Build time-bound multilayer networks, as modeling continues during each phase.

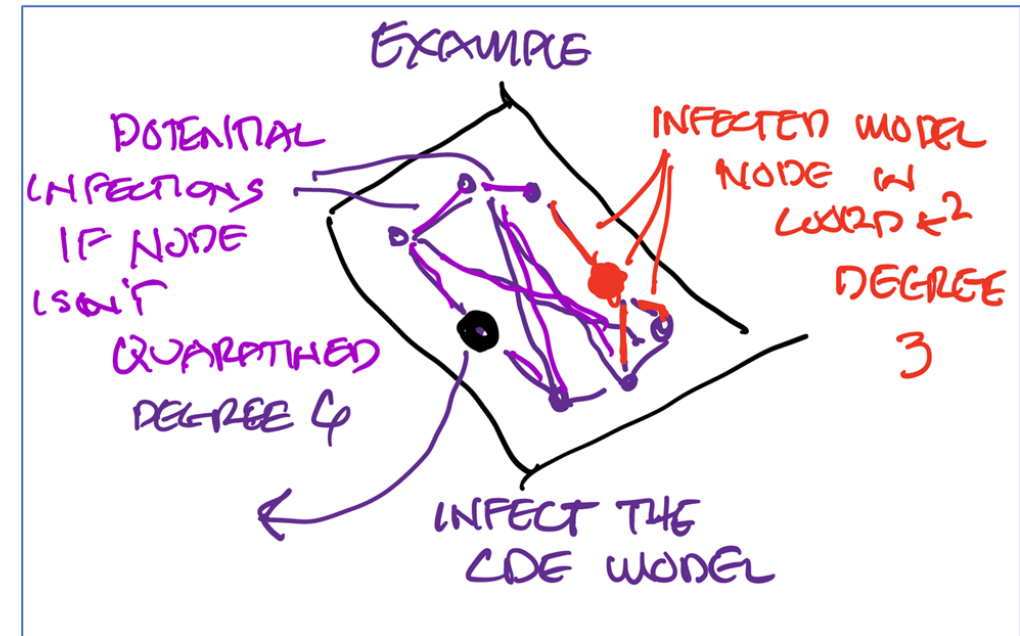# Construction Phase Time-Mapped Multilayer Network

Continuing the Design, Coordination, Build Sequence –Time bound Multi-Layers.
T1 Design Phase, T2 Coordination Phase, T3 Build Phase. This figure shows the
mono-network of each modeling domain (Design, Coordination, and Build), and the
connections between the domains.

# Time-bound multilayer network with Common Data Quarantine Exchange (CDQE)
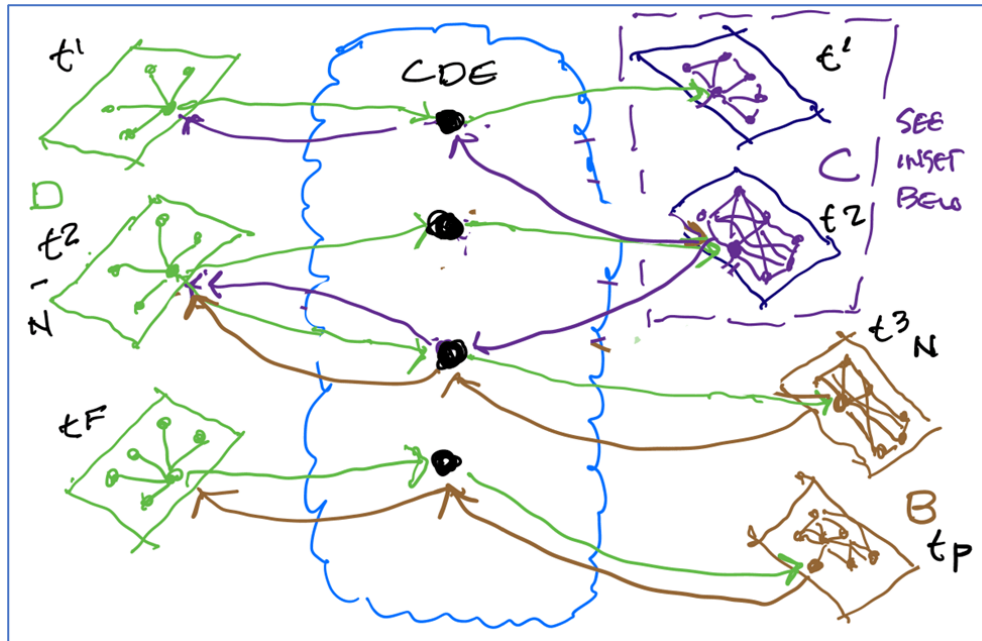
This graphic show the time-bound Design multilayer modeling sharing their models to the CDQE for inspection, prior to sharing to Coordination and Build teams


Detail shows the effect of a tainted or infected model, and the attempt to find, halt the spread and repair the model, and return the model back to CDQE.

Infected Node Removed, and Re- BIM -modeled
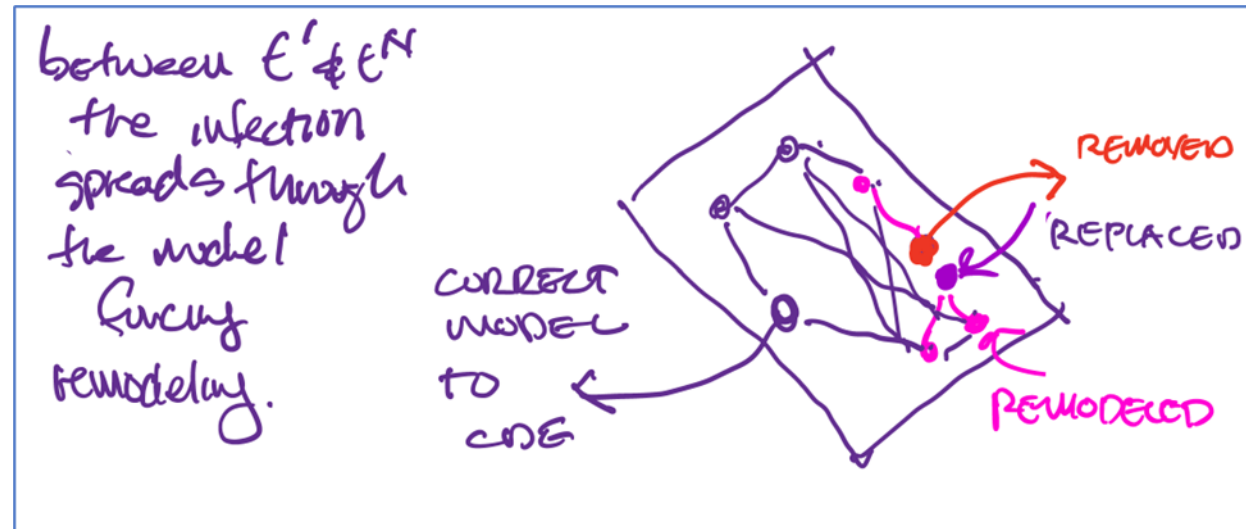
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Results of Time-based modeling with a CDQE
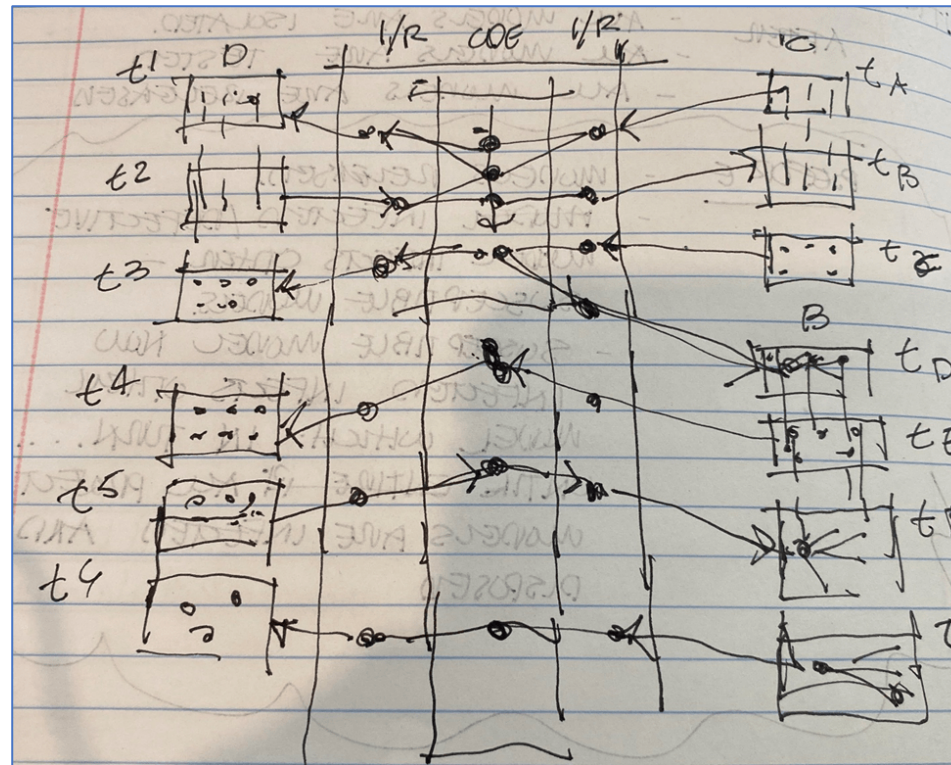
This graphic show the inspection of model nodes and subsequent safe release (I/R) to the CDQE

Time-based Quarantine Layer within the CDQE

Dynamic review algorithms can help mitigate the time needed to ensure accurate model nodes are being shared between team members. This graphic identifies continues review within the CDQE.
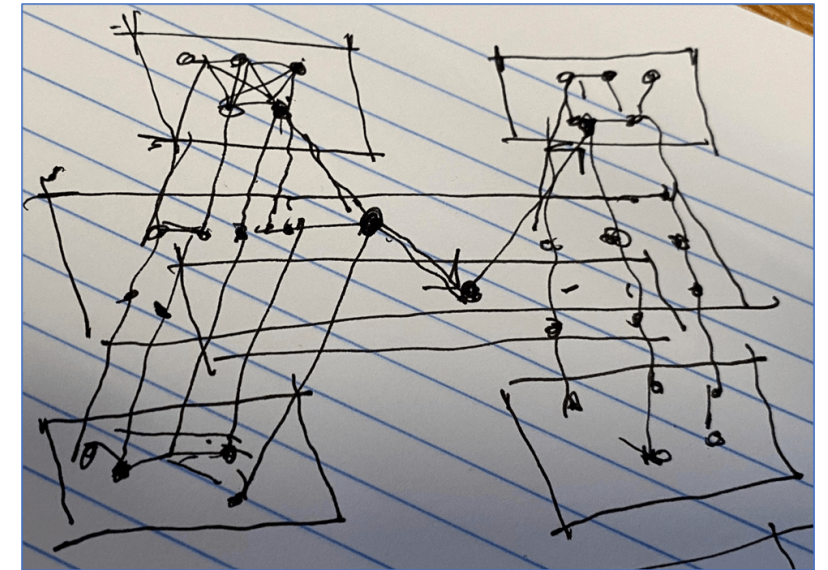
This detail of the graphic shows the percolation detail for shared modeling through the CDQE.

Next Steps

- BIM constitutes the (latest) best opportunity to improve productivity.

- Virtually coordinate and build a project through BIM.

- Reviews, adjustments, and integration can help improve productivity.

- This project reviewed the granular activities of the individual modeling teams, and how tainted information flows between multilevel networks.

- Quarantine, review, and release correct and complete information.

Questions