Untangling the Timeline: Challenges and Opportunities in Supporting Version Control in Modern Computer-Aided Design

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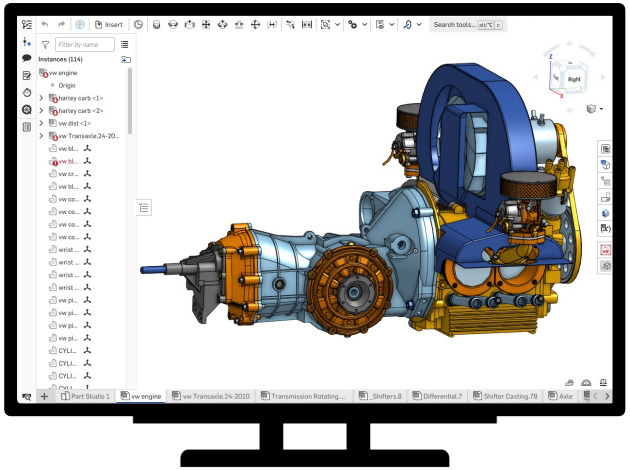
Modern product design and development

Design Ideas

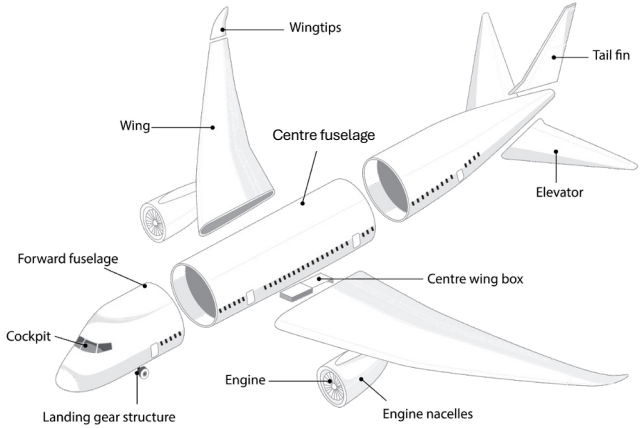


Physical Products

Computer-Aided Design (CAD)

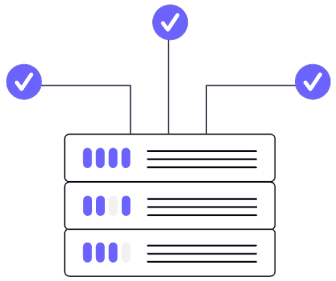
CAD is a complex socio-technical system [1]

A Boeing 747-8 aircraft comprises more than 6 million individual parts, most designed, manufactured and assembled at different locations [2].

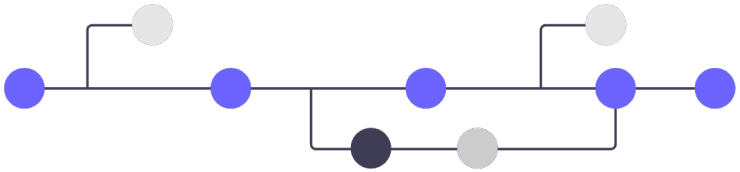


Interdependent components

Increasingly distributed collaboration



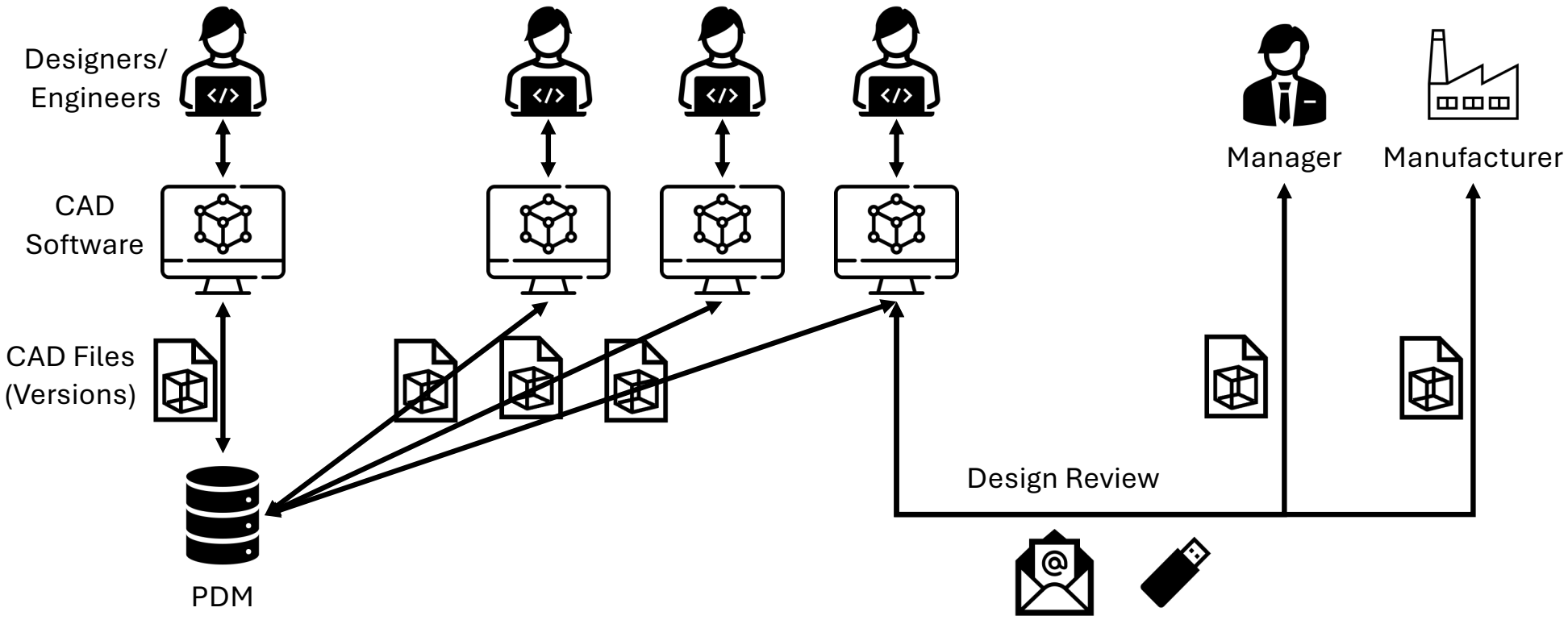
Sophisticated data management



Nonlinear workflows

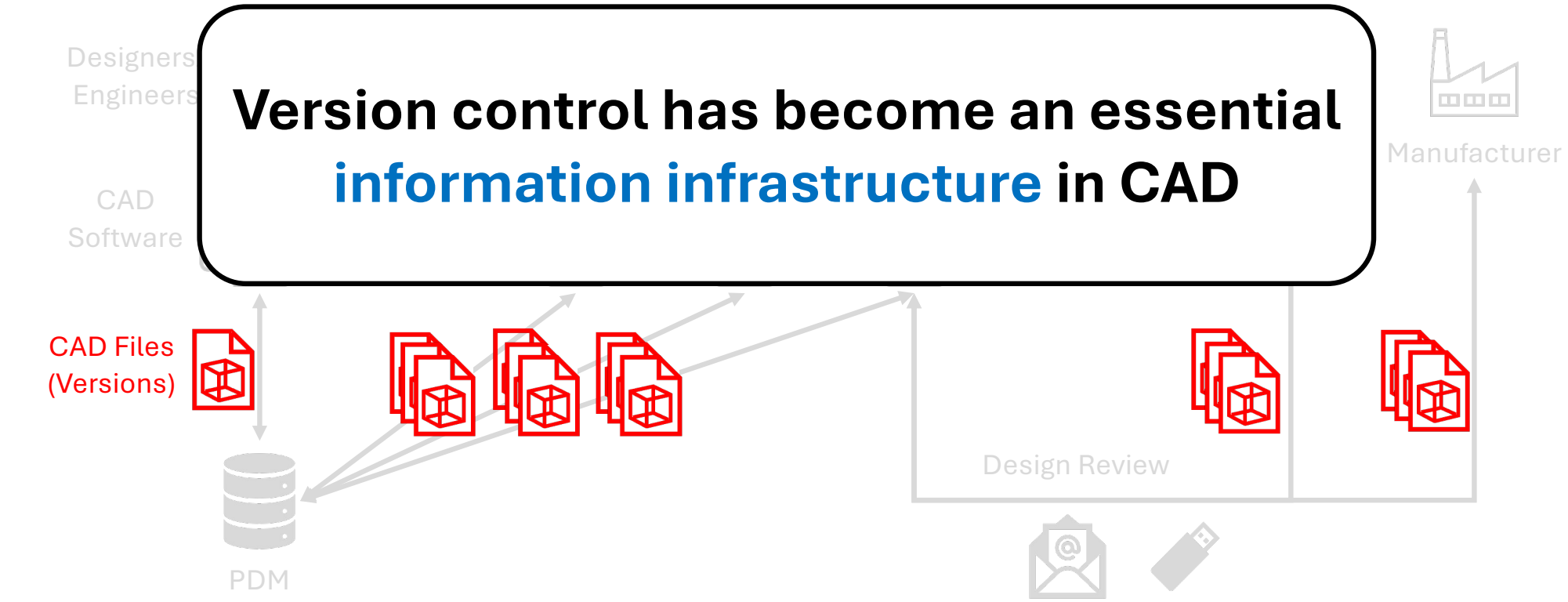
[1] G. Boy, Human-centered design of complex systems: An experience-based approach, *Design Science*, 2017.
[2] https://simpleflying.com/airliners-how-many-parts/

Designing in CAD is an *iterative* process



PDM: product data management system

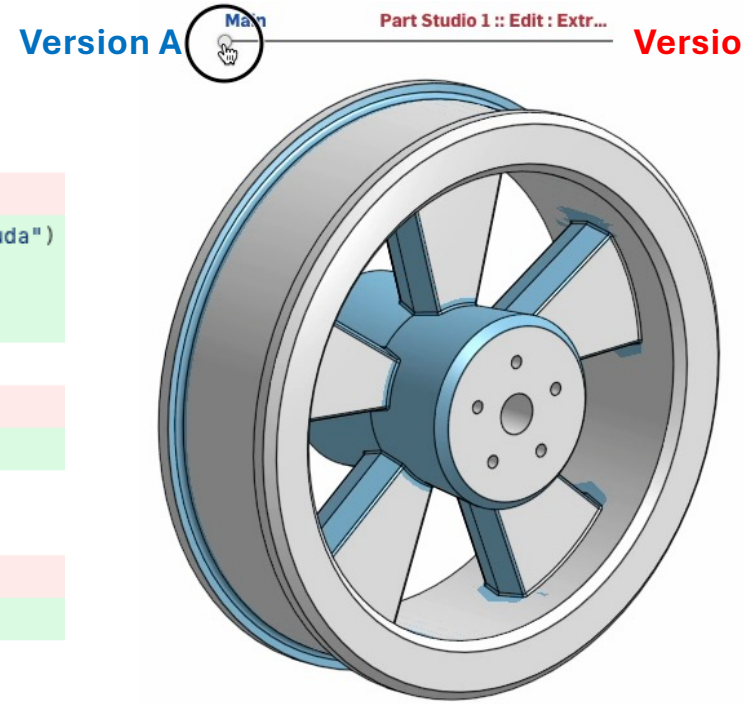
Designing in CAD is an *iterative* process



PDM: product data management system

Software version control ↛ CAD

```
22  34          for safetensor_file in tqdm(safetensor_files):
23  35              file_name = os.path.basename(safetensor_file)
24      -           state_dict = load_file(safetensor_file, device="cuda")
    36  +           current_state_dict = load_file(safetensor_file, device="cuda")
    37  +           loaded_files[file_name] = current_state_dict
    38  +
25  39              new_state_dict = {}
26      -           for weight_name, weight in state_dict.items():
    40  +           for weight_name, weight in current_state_dict.items():
27  41                  if weight_name.endswith("_scale_inv"):
28  42                      continue
29      -               elif weight.element_size() == 1:
    43  +               elif weight.element_size() == 1:  # FP8 weight
30  44                      scale_inv_name = f"{weight_name}_scale_inv"
```



How do we *describe* geometric differences with text?

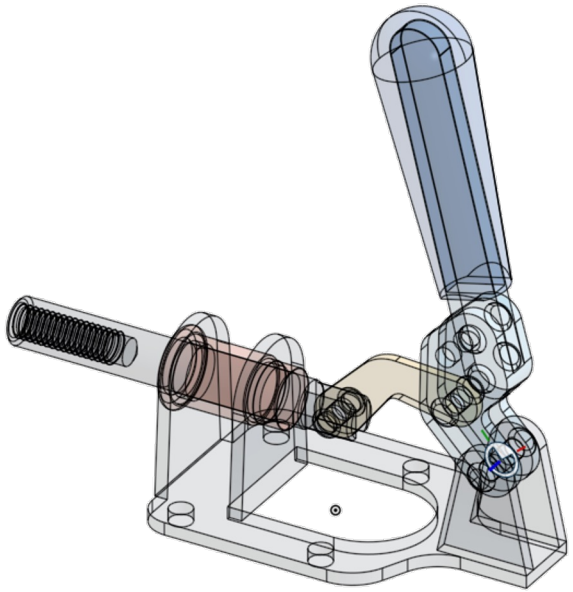
Software version control ↛ CAD

repo:deepseek-ai/DeepSeek-V3 temperature

inference/generate.py — Python · 19

```
19          logits (torch.Tensor): The logits tensor for token predictions.
20          temperature (float, optional): Temperature for scaling logits. Defaults to 1.0.
21
61          logits = model.forward(tokens[:, prev_pos:cur_pos], prev_pos)
62          if temperature > 0:
63              next_token = sample(logits, temperature)
```

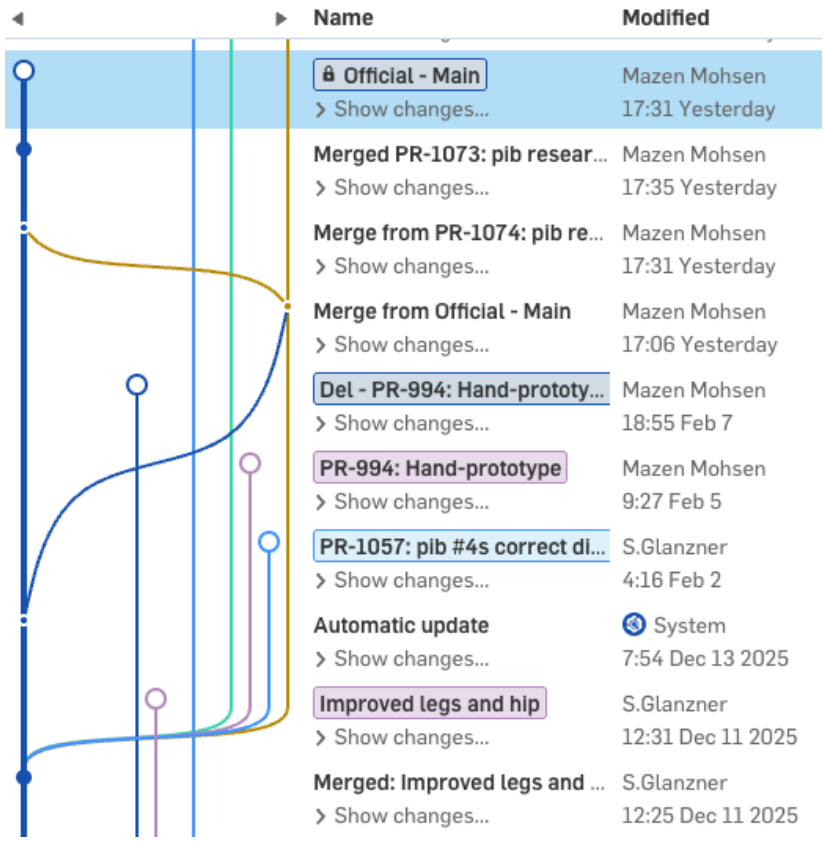
Show 15 more matches



How do we *search* for geometric entities with text?

Version control in CAD remains limited

Objective: a *systematic* understanding of the socio-technical challenges in CAD version control

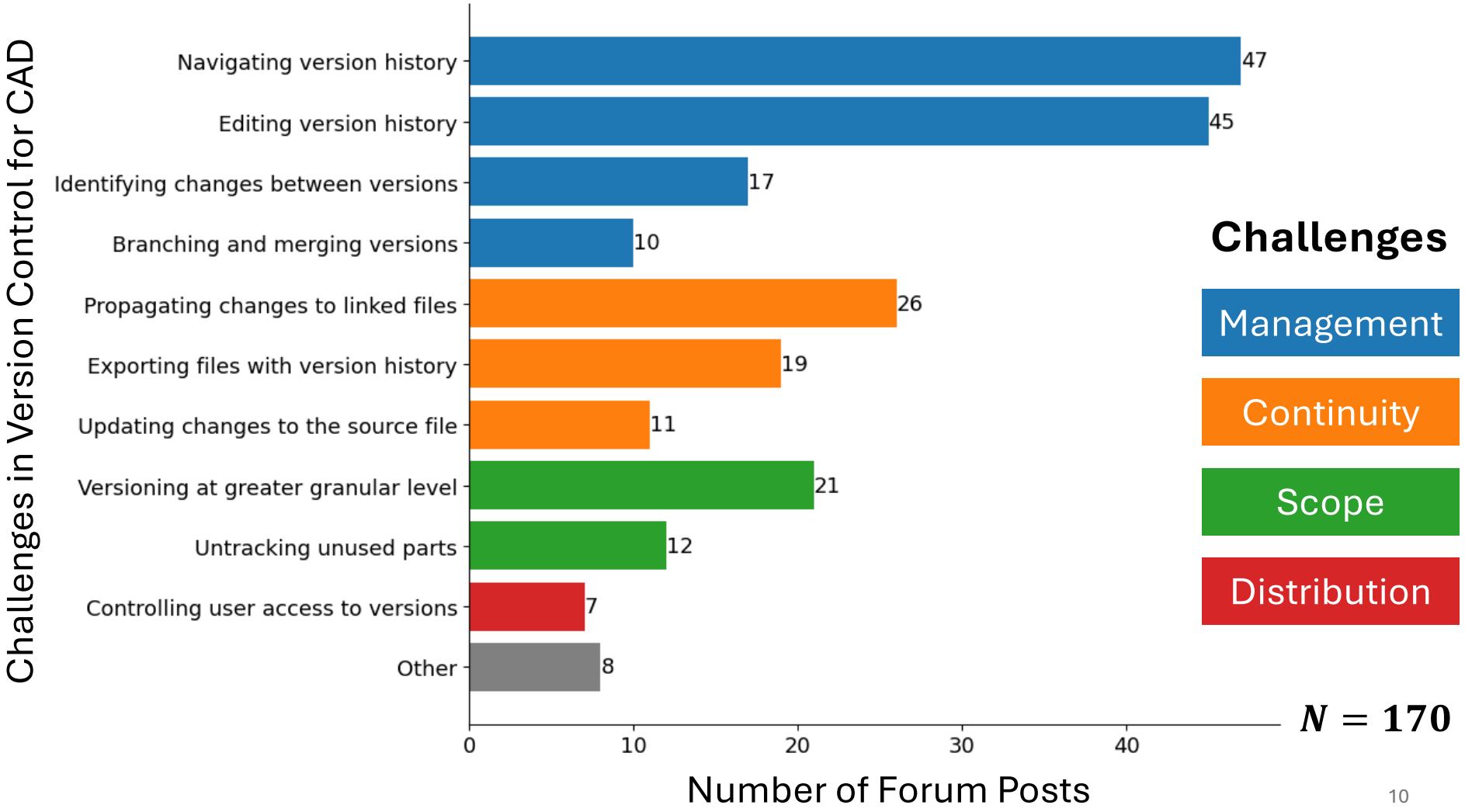


Method: web scraping online forums

CAD modelling software

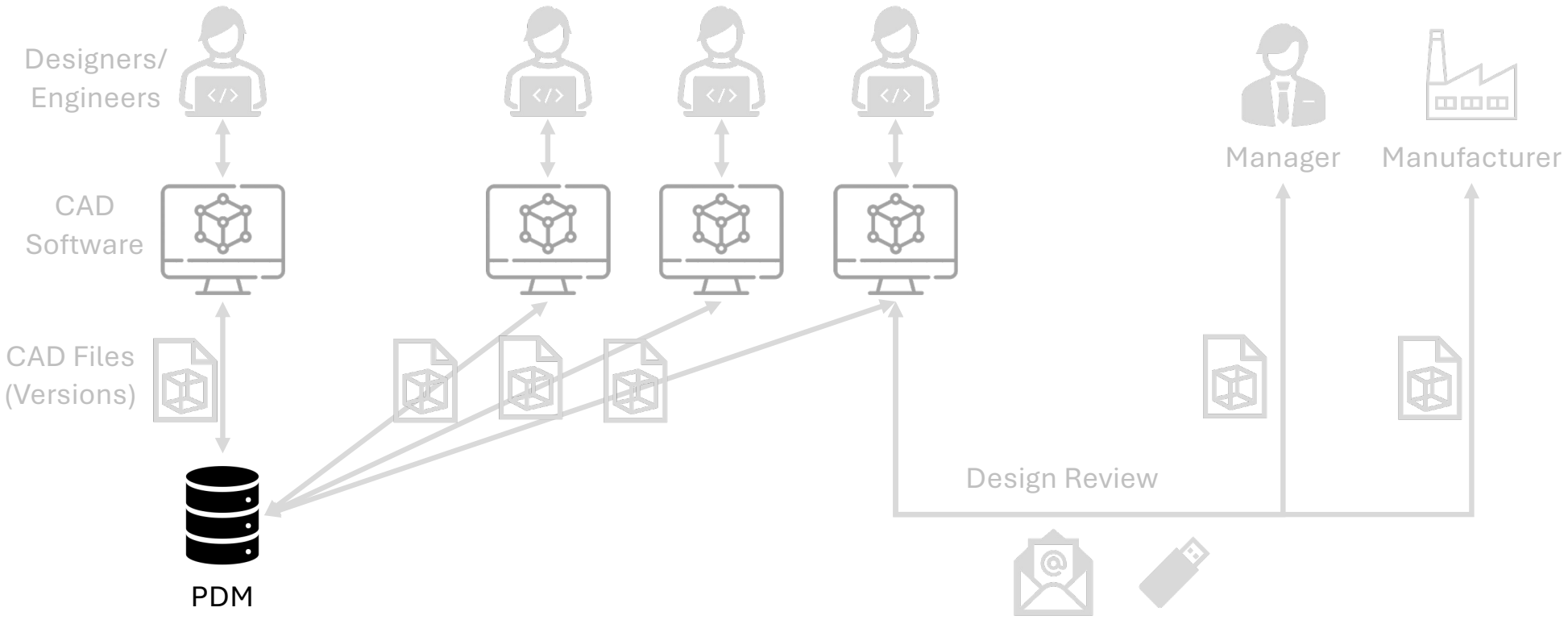
CAD model sharing platforms

Independent forums


Challenges in Version Control for CAD
Navigating version history
Editing version history
Identifying changes between versions
Branching and merging versions
Propagating changes to linked files
Exporting files with version history
Updating changes to the source file
Versioning at greater granular level
Untracking unused parts
Controlling user access to versions
Other
47
45
17
10
26
19
11
21
12
7
8
0
10
20
30
40
Number of Forum Posts
Challenges
Management
Continuity
Scope
Distribution
N = 170

Management-related challenges

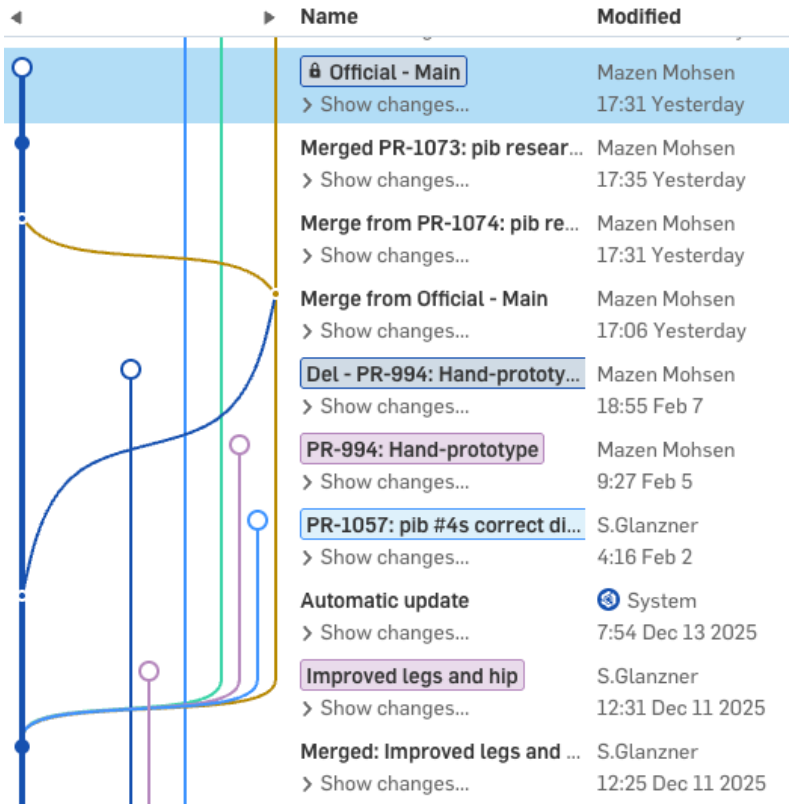
Management



Management-related challenges

Management

> *"Instead of reading through 1000's of lines and sorting through dozens of hastily made versions, I just want to* ***find the last time I was working on a specific feature of a specific part****."*
>
> -- Onshape user (2018)



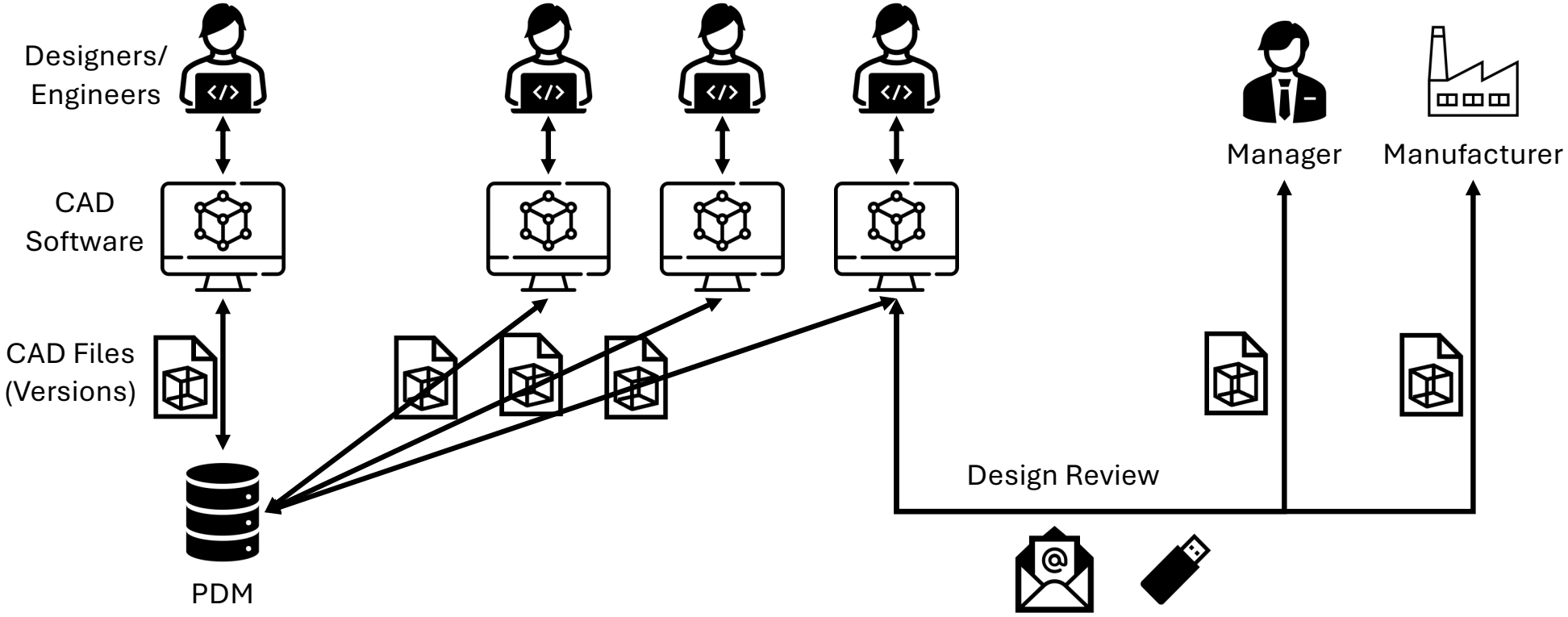
Opportunity: design tools that better support users in articulating the design history as a collaborative record

Cross-boundary collaboration

Continuity

Scope

Distribution

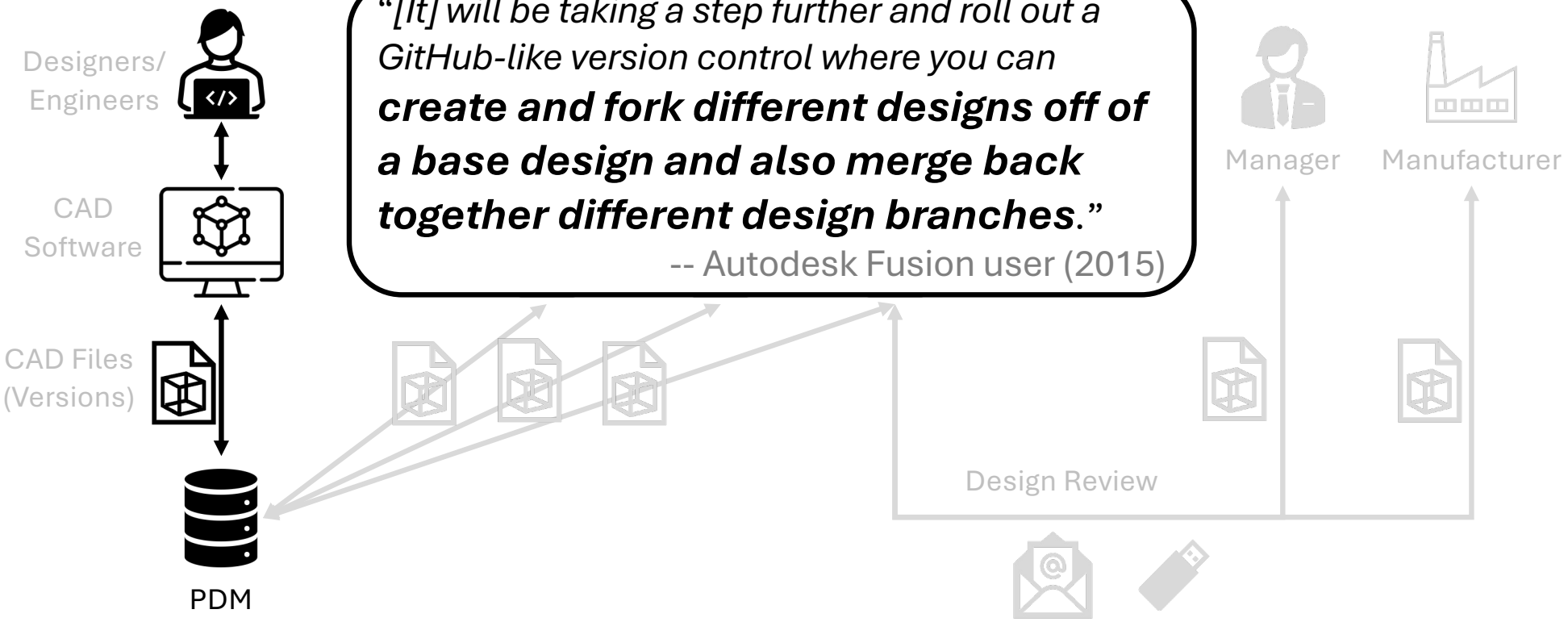


Continuity

Scope

Distribution

Collaboration across branches

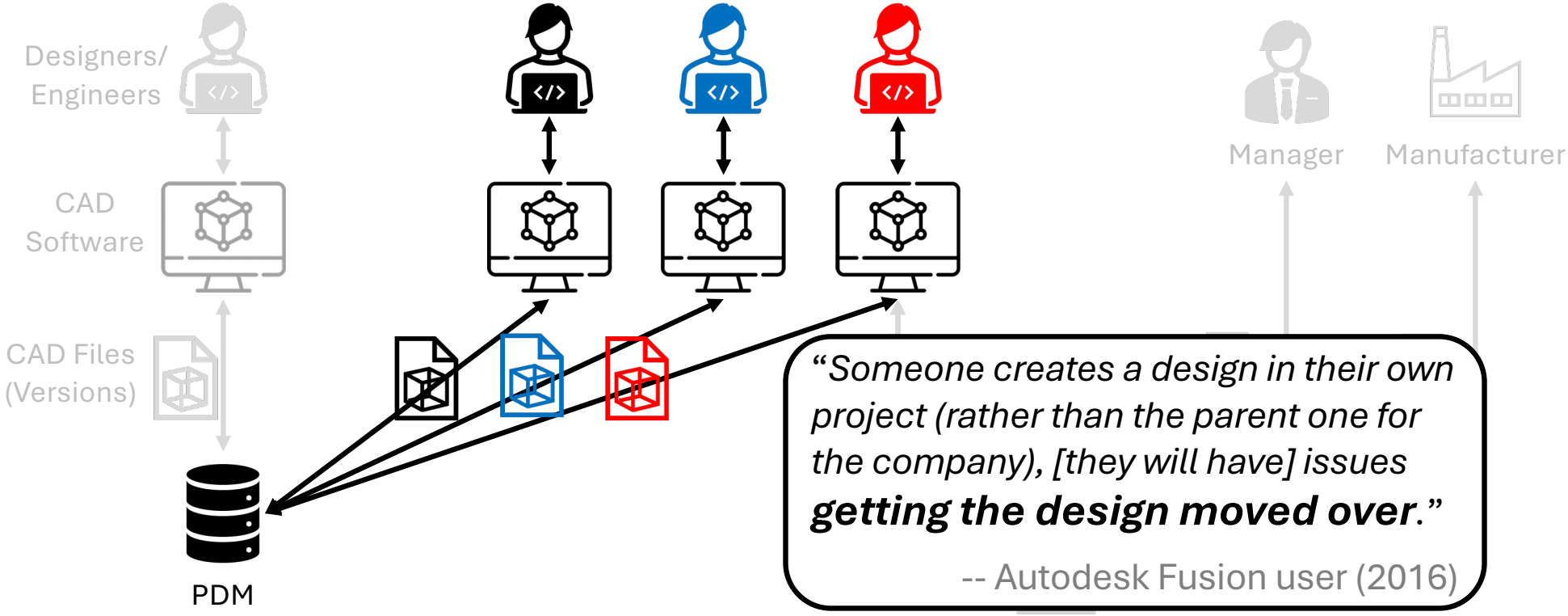


Continuity

Scope

Distribution

Collaboration across projects



"*Someone creates a design in their own project (rather than the parent one for the company), [they will have] issues* ***getting the design moved over****.*"

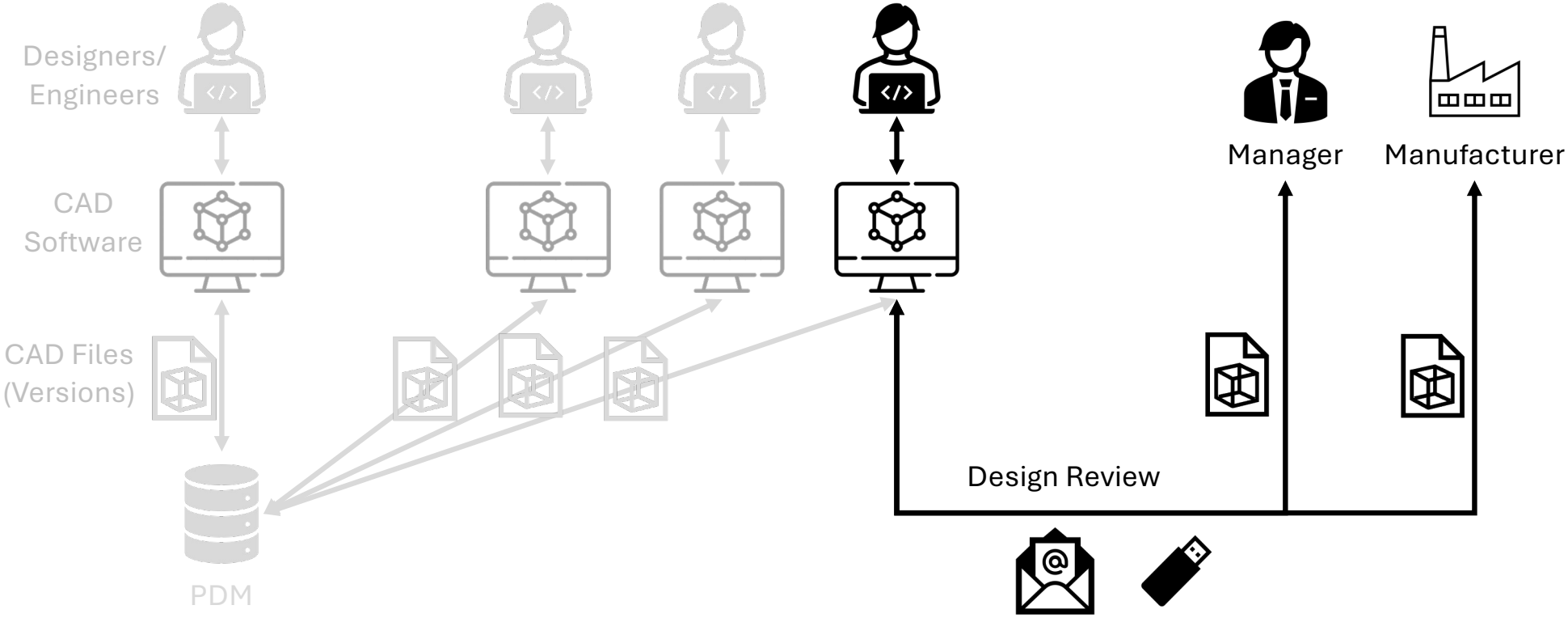
-- Autodesk Fusion user (2016)

Continuity

Scope

Distribution

Collaboration across organizations

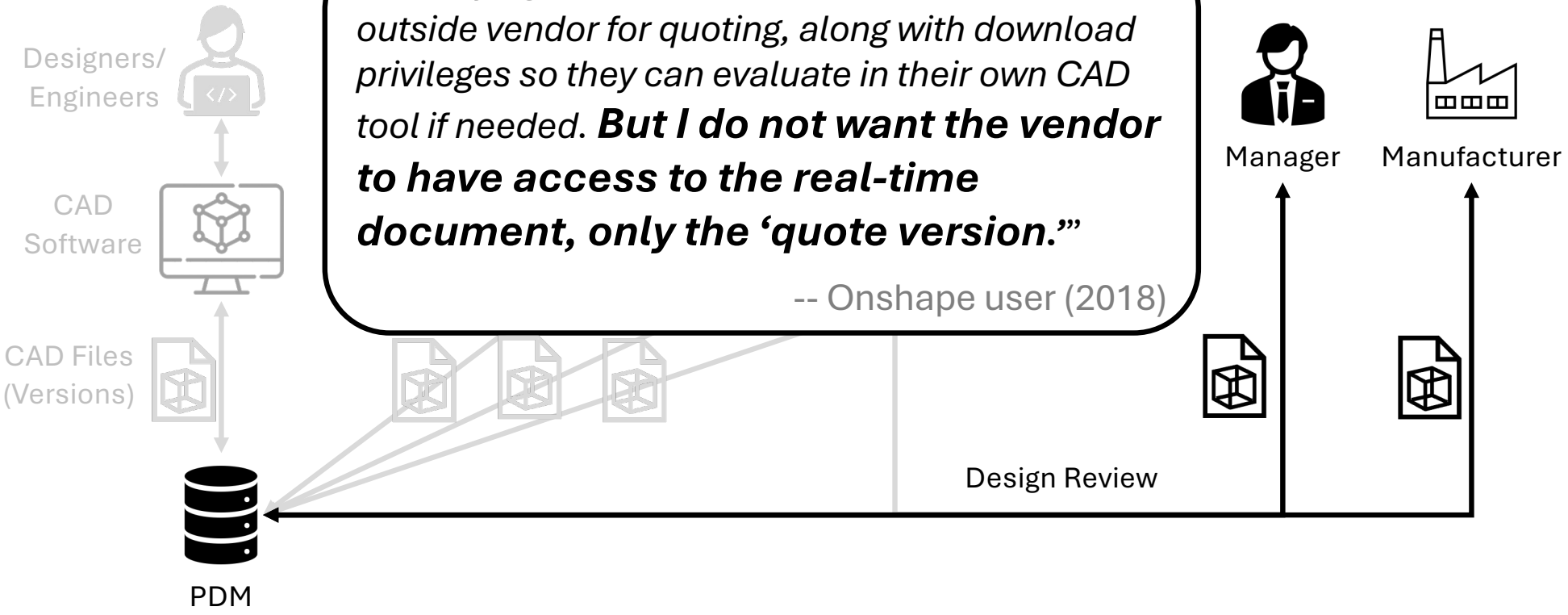


Collaboration across organizations

Continuity | Scope | Distribution

"I am trying to share a version of a document to an outside vendor for quoting, along with download privileges so they can evaluate in their own CAD tool if needed. ***But I do not want the vendor to have access to the real-time document, only the 'quote version.'"***

-- Onshape user (2018)

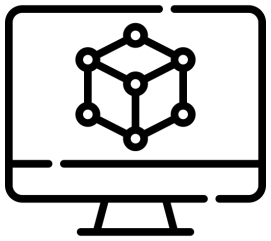


Cross-boundary collaboration

Continuity

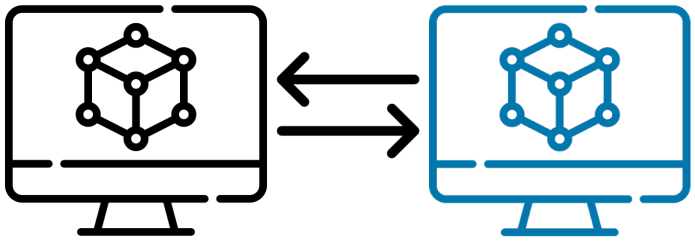
Scope

Distribution



Within the same CAD system

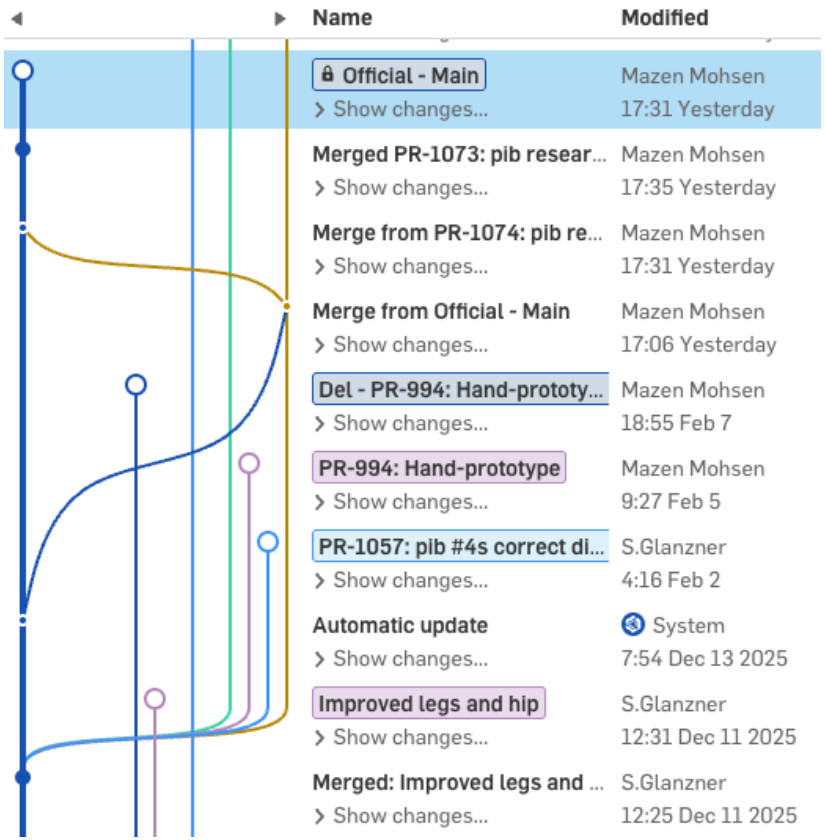
Opportunity: feature development



Across different CAD systems

Opportunity: standard negotiation for data exchange

Version control should NOT ONLY be

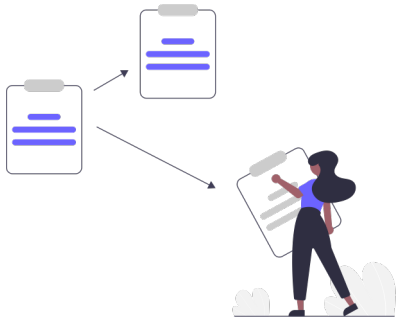


A database that piles up design versions

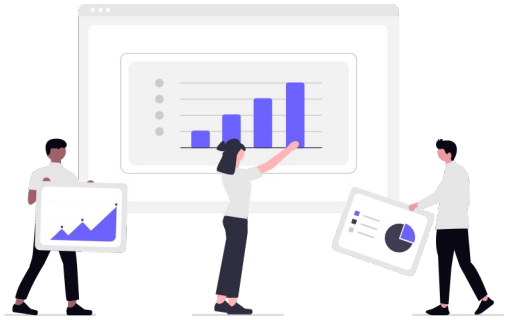
A lock that avoids editing conflicts

A prematurely engineered system with low reflexivity

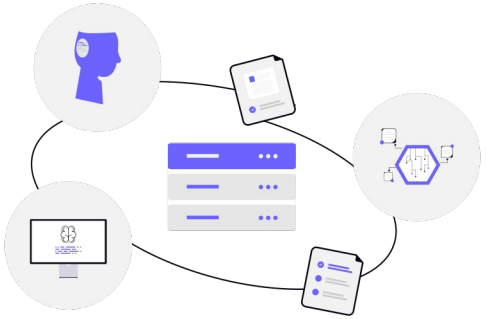
Version control should ALSO be



A collaborative record that articulates the design history



A mechanism that supports cross-boundary collaboration

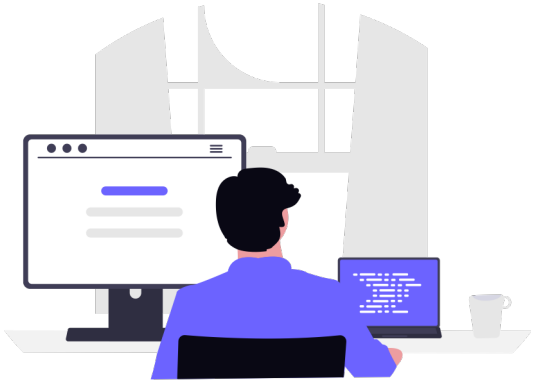


An infrastructure that continues to evolve with user needs

No one-size-fits-all infrastructures in complex socio-technical systems!

Future work

In-situ observational study



Involvement of the software providers

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Challenges

- **Management**
- **Continuity**
- **Scope**
- **Distribution**

Opportunities

- Collaborative record
- Cross-boundary collaboration
- Reflexive infrastructure

Contact me!

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