Soundness Across Formalizations of Decentralized Information Flow Control

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In this capstone project for CSCI 1951x: Formal Proof and Verification, I modeled the semantics of Decentralized Information Flow Control (DIFC), as presented in the paper 'Complete, Safe Information Flow with Decentralized Labels' (1998) by Andrew C. Myers and Barbara Liskov. I used Lean 3 as an automated proof assistant and modeling language throughout this project.

I used inductive predicates to model incremental and larger relabelings for a simplified relabeling rule (the subset relabeling rule) and a complete one (the complete relabeling rule). I included and proved a set of example theorems to show how we can use these inductive predicates to prove the validity of certain relabelings. Further, I defined closed-form rules and functions that help model the complete relabeling rule, and close out the project by proving that this rule is sound.

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1  -- Example: here, this relabeling replaces an owner with a principal that acts for
2  -- the previous owner. It also removes a reader, as we could earlier.
3  def ph_single : PHierarchy := [10 > 1]
4  def cl1 : Label := {policies := [{owner := 1, readers := {2}}]}
5  def cl2 : Label := {policies := [{owner := 18, readers := {}}]}
6
7  theorem eg_can_replace_owner_and_remove_reader : CompleteRelabel ph_single cl1 cl2 :=
8       by
9       apply CompleteRelabel.trans ph_single cl1 cl2 {policies := [{owner := 1, readers := {}}]}
10       { apply CompleteRelabel.direct
11         have hincr : IncrSubRelabel cl1 {policies := [{owner := 1, readers := {}}]} :=
12           by
13             apply IncrSubRelabel.remove_reader
14             apply Exists.intro {owner := 1, readers := {2}}
15             apply Exists.intro {owner := 1, readers := {}}
16             apply Exists.intro 2
17             simp
18             intro m_in_cl1
19             apply Exists.intro 2
20             simp
21             apply IncrRelabel.subset
22             exact hincr
23       }{ apply IncrRelabel.replace_owner
24       apply Exists.intro {owner := 1, readers := {}}
25       apply Exists.intro {owner := 18, readers := {}}
26       apply Exists.intro 1
27       simp
28     }
29 done
```

Pictured above is an example theorem I stated and proved using my formalization of labeling rules for DIFC.