Definition (Entity regulation). *An entity regulation identifies the entities (i.e., users or roles) whose behavior is being regulated by a given policy. Its input parameters are one policy and the set of relationships defined between entities and contexts that are represented in the domain ontology.*

$$Entity\ regulation = Policy \times Rel \rightarrow SR$$

Definition (Object regulation). *An object regulation identifies the objects used by the behavior being regulated by a given policy. Its input parameters are one policy and the relationships defined views and objects that are represented in the domain ontology.*

$$Object\ regulation = Policy \times Rel \rightarrow O$$

I. CORRECTNESS OF POLICY PROPAGATION

The aim of this section is to demonstrate that, given a set of policies, the policy propagation restrictions specified in Section 3 preserve conflicts in the given set of policies, i.e., the propagations do not include or remove any conflict. Essentially, the propagation restrictions only require a given set of policies to make explicit regulations that were otherwise implicit as they are defined at the level of composite elements such as role or organization. In other words, no new regulation is created or removed by propagation.

Lemma 1 (Play propagation correctness). Play propagation preserves regulation.

Proof. Let P be a set of policies with p∈P, p= ⟨kp, org, r, aa, ov, ac, dc⟩, that is, p is a policy defined in the context of an organization o and applied to role r. Therefore, by applying entity regulation function (see Definition 2), p governs the behavior of all users playing role r in o. By Definition 5, the propagation of p requires policies pu = ⟨kp, org, s, aa, ov, ac, dc⟩, where play(org,s,r), also to be in P. The propagation of p does not imply any new regulation in P that was not already specified by p. The users whose behaviors were regulated by p are exactly the same users whose behaviors are being regulated by the set of pe. In addition, since pe is propagated based on p, its other parameters have not been changed, as shown in Definition 5.

Lemma 2 (Ownership propagation correctness). Ownership propagation preserves regulation.

Proof. Let P be a set of policies with p∈P, p = ⟨kp, org,_,aa, ov, ac, dc⟩,, that is, p is a policy defined in the context of an organization org. Therefore, by applying entity regulation function (see Definition 2), p governs the behavior of all role r played in org. By Definition 7, the propagation of p requires policies pw = ⟨kp,org,r,aa,ov,ac,dc⟩, where ownership(org,r), also to be in P. The propagation of p does not imply any new regulation in P that was not already specified by p. The roles governed by p are exactly the same roles governed by the set of pw. In addition, since pw is propagated based on p, its other parameters have not been changed, as shown in Definition 7.

Lemma 3 (OrgHierarchy propagation correctness). OrgHierarchy propagation preserves regulation.

Proof. Let P be a set of policies with p∈P, p= ⟨kp, org,_, aa, ov, acc, dac⟩, that is, p is a policy defined in the context of an organization org without addressing a specific subject in the organization. Therefore, by applying entity regulation function (see Definition 2), p governs the behavior of all suborganizations of org. By Definition 9, the propagation of p requires policies ps = (⟨kp, org, suborg, aa, ov, acc, dac⟩, where orghierarchy(org, suborg), also to be in P. The propagation of p does not imply any new regulation in P that was not already specified by p. The suborganizations whose behaviors were regulated by p are exactly the same suborganizations whose behaviors are being regulated by the set of ps. In addition, since ps is propagated based on p, its other parameters have not been changed, as shown in Definition 9.

Lemma 4 (RoleHierarchy propagation correctness). RoleHierarchy propagation preserves regulation.

Proof. Let P be a set of policies with p∈P, p = ⟨kp, org, r, aa, ov, ac, dc⟩, that is, p is a policy that states a superrole. Therefore, by applying entity regulation function (see Definition 2), p applies to all roles linked by role hierarchy relationship to superrole. By Definition 11, the propagation of p requires policies pr = ⟨kp,org,r,aa,ov,ac,dc⟩, where rolehierarchy(superrole, subrole), also to be in P. The propagation of p does not imply any new regulation in P that was not already specified by p. The roles implicitly identified in p are exactly the same roles explicitly identified by the set of pr. In addition, since pr is propagated based on p, its other parameters have not been changed, as shown in Definition 11.

Lemma 5 (Object composition correctness). Object composition propagation preserves regulation. policies.

Proof. Let P be a set of policies with p∈P, p = ⟨kp, org, sr, aa, v, ac, dc⟩, that is, p is a policy that states a vision and not a set of objects. Therefore, by applying objects regulation function (see Definition 3), p applies to all objects linked by the object composition relationship to v. By Definition 13, the propagation of p requires policies po = ⟨kp, org, sr, aa, o, ac, dc⟩, where objectComposition(v,o,org), also to be in P. The propagation of p does not imply any new regulation in P that was not already specified by p. The objects implicitly identified in p are exactly the same objects explicitly identified by the set of po. In addition, since po is propagated based on p, its other parameters have not been changed, as shown in Definition 13.

Theorem 1 (Policy propagation correctness). Policy propagation does not add or remove regulation of a given set of policies.

Proof. By lemmata 1 to 5.