**Bank Policy Test Case**

**1. Introduction**

The Bank policy is an administrative role-based access-control policy based on a large bank system which includes several branches [1]. There are 531 roles and 5126 rules in the original policy [2].

The test cases described in this document are derived from the Bank policy. Each test case consists of rules from the original Bank policy and rules or resources created by us (which are highlighted) to embed errors.

**2. Basic Test Case without Error**

**Roles:** Managerial (FA\_Head, FA\_GM), Employee (employee\_one, employee\_two)

Non\_Managerial (FA\_Asst, FA\_Specialist, FA\_Senior, FA\_Junior, FA\_Clerk) FinancialAnalyst(FA\_Role)

**Resource:** Order (PurchaseOrder\_One)

**Action**: CAN\_BE\_ASSIGNED\_TO, Create, Approve

**EnvironmentStatus:** isFA\_Asst (True, False), isFA\_Specialist (True, False), isFA\_Senior (True, False), isFA\_Junior (True, False), isFA\_Clerk (True, False)

**Inheritance:** Beneficiary (employee\_one, employee\_two), Inherited Value (FA\_Role)

**Rules:**

**FA\_RolePolicy:**

**\*\*\*rules for assigning FA\_Role to FA\_Asst\*\*\***  
(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk:False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Specialist\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Senior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Junior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Clerk\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

**\*\*\*rules for FA\_Role accessing to Order\*\*\***

(FA\_Role, isFA\_Senior: True, Create, PurchaseOrder\_One)->Permit

(FA\_Role, Approve, PurchaseOrder\_One)->Deny

**ManagerialPolicy:**

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk) ->Permit

(FA\_GM, isFA\_Asst: False#isFA\_Specialist: False#isFA\_Senior: False#isFA\_Junior: False#isFA\_Clerk: False, Approve, PurchaseOrder\_One)->Permit

(FA\_GM, Create, PurchaseOrder\_One) ->Deny

(FA\_Head, Approve, PurchaseOrder\_One)->Permit

(FA\_Head, Create, PurchaseOrder\_One) ->Deny

**3. Test case with Error Type #1 <conflict>**

**Roles:** Managerial (FA\_Head, FA\_GM), Employee (employee\_one, employee\_two,FA\_GM(NOTE: this modification is used to generate type#1 error. It will cause conflicts of FA\_GM being assigned to other Non\_Managerial roles and accessing to the Order))

Non\_Managerial (FA\_Asst, FA\_Specialist, FA\_Senior, FA\_Junior, FA\_Clerk) FinancialAnalyst(FA\_Role)

**Resource:** Order (PurchaseOrder\_One)

**Action:** CAN\_BE\_ASSIGNED\_TO, Create, Approve

**EnvironmentStatus:** isFA\_Asst (True, False), isFA\_Specialist (True, False), isFA\_Senior (True, False), isFA\_Junior (True, False), isFA\_Clerk (True, False)

**Inheritance:** Beneficiary (employee\_one, employee\_two), Inherited Value (FA\_Role)

**Rules:**

**FA\_RolePolicy:**

**\*\*\*rules for assigning FA\_Role to FA\_Asst\*\*\***(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk:False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Specialist\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Senior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Junior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Clerk\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

**\*\*\*rules for FA\_Role accessing to Order\*\*\***

(FA\_Role, isFA\_Senior: True, Create, PurchaseOrder\_One,)->Permit

(FA\_Role, Approve, PurchaseOrder\_One)->Deny

**ManagerialPolicy:**

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk) ->Permit

(FA\_GM, isFA\_Asst: False#isFA\_Specialist: False#isFA\_Senior: False#isFA\_Junior: False#isFA\_Clerk: False, Approve, PurchaseOrder\_One)->Permit

(FA\_GM, Create, PurchaseOrder\_One) ->Deny (NOTE: conflict with the correspondent rule in FA\_RolePolicy)

(FA\_Head, Approve, PurchaseOrder\_One)->Permit

(FA\_Head, Create, PurchaseOrder\_One) ->Deny

**Property** **used to check errors:**

(Managerial = FA\_GM & Employee = FA\_GM) & (isFA\_Asst = True & isFA\_Specialist = False & (isFA\_Senior = False & isFA\_Junior = False & isFA\_Clerk = False) & (Action = CAN\_BE\_ASSIGNED\_TO) & (Non\_Managerial = FA\_Senior) -> decision = Permit

(Managerial = FA\_GM & Employee = FA\_GM) & (FinancialAnalyst = FA\_Role) & (Order = PurchaseOrder\_One) & (Action = Create) & (isFA\_Senior = True) -> decision = Permit

**Result on ACPT (NuSMV Verification for Merged Policies):**

(Managerial = FA\_GM & Employee = FA\_GM) & (isFA\_Asst = True & isFA\_Specialist = False & (isFA\_Senior = False & isFA\_Junior = False & isFA\_Clerk = False) & (Action = CAN\_BE\_ASSIGNED\_TO) & (Non\_Managerial = FA\_Senior) -> decision = Permit **in FA\_RolePolicy is True**

(Managerial = FA\_GM & Employee = FA\_GM) & (isFA\_Asst = True & isFA\_Specialist = False & (isFA\_Senior = False & isFA\_Junior = False & isFA\_Clerk = False) & (Action = CAN\_BE\_ASSIGNED\_TO) & (Non\_Managerial = FA\_Senior) -> decision = Permit **in ManagerialPolicy is False**

(Managerial = FA\_GM & Employee = FA\_GM) & (FinancialAnalyst = FA\_Role) & (Order = PurchaseOrder\_One) & (Action = Create) & (isFA\_Senior = True) -> decision = Permit **in FA\_RolePolicy is True**

(Managerial = FA\_GM & Employee = FA\_GM) & (FinancialAnalyst = FA\_Role) & (Order = PurchaseOrder\_One) & (Action = Create) & (isFA\_Senior = True) -> decision = Permit **in ManagerialPolicy is False**

**4. Test Case with Error Type #2 <no object>**

**Roles:** Managerial (FA\_Head, FA\_GM), Employee (employee\_one, employee\_two)

Non\_Managerial (FA\_Asst, FA\_Specialist, FA\_Senior, FA\_Junior, FA\_Clerk) FinancialAnalyst (FA\_Role)

**Resource:** Order (PurchaseOrder\_One, PurchaseOrder\_Two (NOTE: this resource is added to generate type#2 error, because it is not protected by any rules))

**Action:** CAN\_BE\_ASSIGNED\_TO, Create, Approve

**EnvironmentStatus:** isFA\_Asst (True, False), isFA\_Specialist (True, False), isFA\_Senior (True, False), isFA\_Junior (True, False), isFA\_Clerk (True, False)

**Inheritance:** Beneficiary (employee\_one, employee\_two), Inherited Value (FA\_Role)

**Rules:**

**FA\_RolePolicy:**

**\*\*\*rules for assigning FA\_Role to FA\_Asst\*\*\***(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk:False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Specialist\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Senior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Junior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Clerk\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

**\*\*\*rules for FA\_Role accessing to Order\*\*\***

(FA\_Role, isFA\_Senior: True, Create, PurchaseOrder\_One,)->Permit

(FA\_Role, Approve, PurchaseOrder\_One)->Deny

**ManagerialPolicy:**

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk) ->Permit

(FA\_GM, isFA\_Asst: False#isFA\_Specialist: False#isFA\_Senior: False#isFA\_Junior: False#isFA\_Clerk: False, Approve, PurchaseOrder\_One)->Permit

(FA\_GM, Create, PurchaseOrder\_One) ->Deny

(FA\_Head, Approve, PurchaseOrder\_One)->Permit

(FA\_Head, Create, PurchaseOrder\_One) ->Deny

**Property used to check the error:**

(Employee = employee\_one) &(isFA\_Senior = True) & (Action = Create) & (Order = PurchaseOrder\_Two) & -> decision = Permit

**Result on ACPT (NuSMV Verification for Combined Policies):**

(Employee = employee\_one) & (isFA\_Senior = True) & (Action = Create) & (Order = PurchaseOrder\_Two) & -> decision = Permit  **is False**

**5. Test case with Error Type #3 <undecided>**

**Roles:** Managerial (FA\_Head, FA\_GM), Employee (employee\_one, employee\_two)

Non\_Managerial (FA\_Asst, FA\_Specialist, FA\_Senior, FA\_Junior, FA\_Clerk) FinancialAnalyst(FA\_Role)

**Resource:** Order (PurchaseOrder\_One, PurchaseOrder\_Two (NOTE: this resource is added to generate type#3 error. Only the FA\_Role is assigned access to PurchaseOrder\_Two, but FA\_GM and FA\_Head are not assigned access to to PurchaseOrder\_Two.))

**Action:** CAN\_BE\_ASSIGNED\_TO, Create, Approve

**EnvironmentStatus:** isFA\_Asst (True, False), isFA\_Specialist (True, False), isFA\_Senior (True, False), isFA\_Junior (True, False), isFA\_Clerk (True, False)

**Inheritance:** Beneficiary (employee\_one, employee\_two), Inherited Value (FA\_Role)

**Rules:**

**FA\_RolePolicy:**

**\*\*\*rules for assigning FA\_Role to FA\_Asst\*\*\***(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk:False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:True&isFA\_Senior:False&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:True&isFA\_Junior:False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist:False&isFA\_Senior:False&isFA\_Junior:True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Specialist\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist )->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: True& isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: True& isFA\_Junior: False& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False &isFA\_Senior: False& isFA\_Junior: True& isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Senior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Senior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Junior\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: True, CAN\_BE\_ASSIGNED\_TO, FA\_Junior)->Permit

**\*\*\*rules for assigning FA\_Role to FA\_Clerk\*\*\***

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: True&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: True&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: True&isFA\_Senior: False&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

(FA\_Role, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: True&isFA\_Junior: True&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk)->Permit

**\*\*\*rules for FA\_Role accessing to Order\*\*\***

(FA\_Role, isFA\_Senior: True, Create, PurchaseOrder\_One)->Permit

(FA\_Role, Approve, PurchaseOrder\_One)->Deny

(FA\_Role, isFA\_Senior: True, Create, PurchaseOrder\_Two)->Permit

(FA\_Role, Approve, PurchaseOrder\_Two)->Deny (NOTE: rules for FA\_Role accessing to PurchaseOrder\_Two)

**ManagerialPolicy:**

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Asst) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Specialist) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Senior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Junior) ->Permit

(FA\_GM, isFA\_Asst: False&isFA\_Specialist: False&isFA\_Senior: False&isFA\_Junior: False&isFA\_Clerk: False, CAN\_BE\_ASSIGNED\_TO, FA\_Clerk) ->Permit

(FA\_GM, isFA\_Asst: False#isFA\_Specialist: False#isFA\_Senior: False#isFA\_Junior: False#isFA\_Clerk: False, Approve, PurchaseOrder\_One)->Permit

(FA\_GM, Create, PurchaseOrder\_One) ->Deny

(FA\_Head, Approve, PurchaseOrder\_One)->Permit

(FA\_Head, Create, PurchaseOrder\_One) ->Deny

**Prpperty used to check the error:**

(Employee = employee\_one)) & (isFA\_Senior = True) & (Action = Create) & (Order = PurchaseOrder\_Two-> decision = Permit (NOTE: this property is added to make a comparison with the second propperty)

(Managerial = FA\_GM) & (Action = Approve) & (Order = PurchaseOrder\_Two) -> decision = Permit

**Result on ACPT (NuSMV Verification for Combined Policies):**

(Employee = employee\_one)) & (isFA\_Senior = True) & (Action = Create) & (Order = PurchaseOrder\_Two-> decision = Permit **is True**

(Managerial = FA\_GM) & (Action = Approve) & (Order = PurchaseOrder\_Two) -> decision = Permit **is False**

**References**

[1] Jayaraman, Karthick, Vijay Ganesh, Mahesh Tripunitara, Martin C. Rinard, and Steve J. Chapin. "Arbac policy for a large multi-national bank." arXiv preprint arXiv: 1110.2849 (2011).

[2] http://mohawk.googlecode.com/files/casestudy.tar.gz