FeatureX FM to Manual FM comparison

June 19, 2018

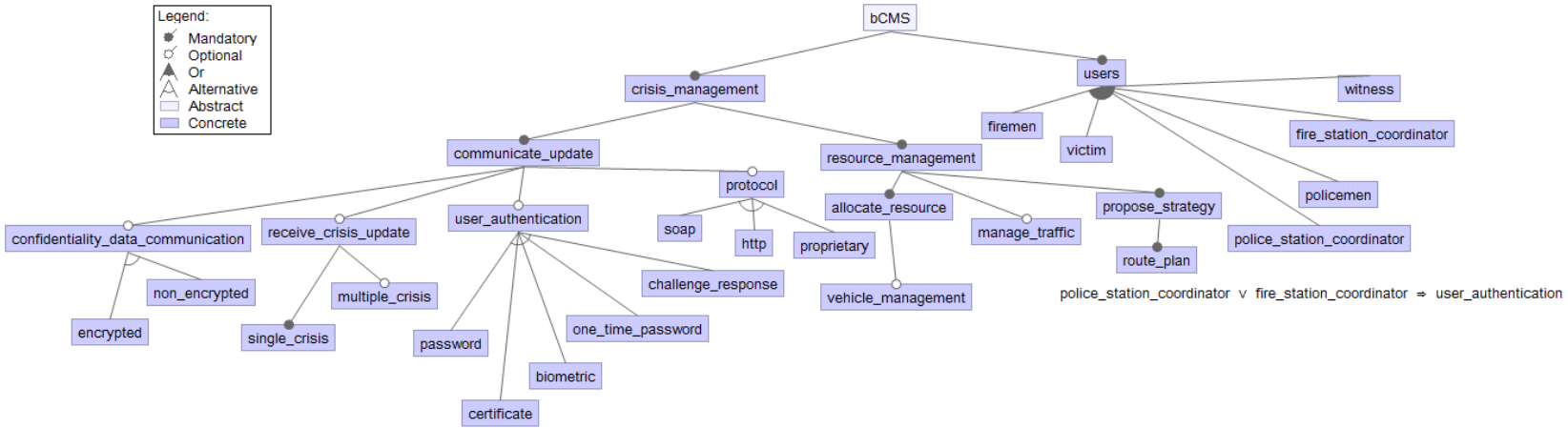

Figure 1: bCMS - benchmark FM (manually created in FeatureIDE).

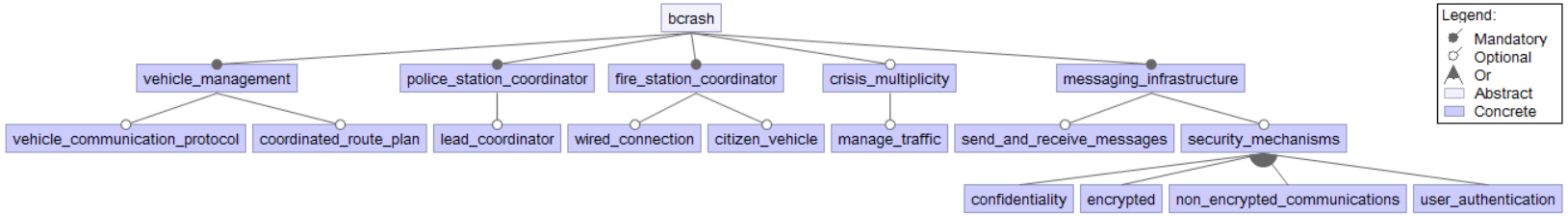

Figure 2: bCMS - FeatureX FM (manually created in FeatureIDE).

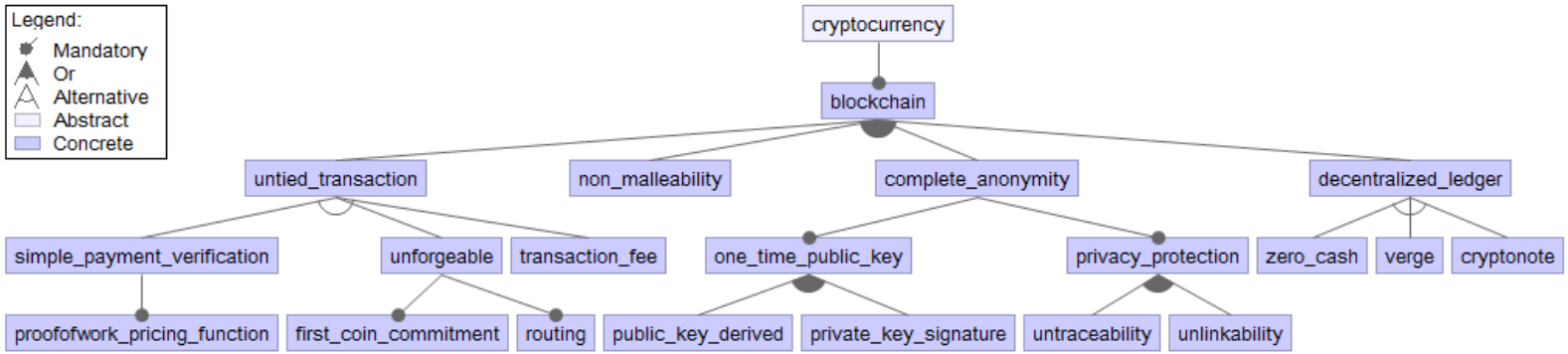

Figure 3: Cryptocurrency - benchmark FM (manually created in FeatureIDE).

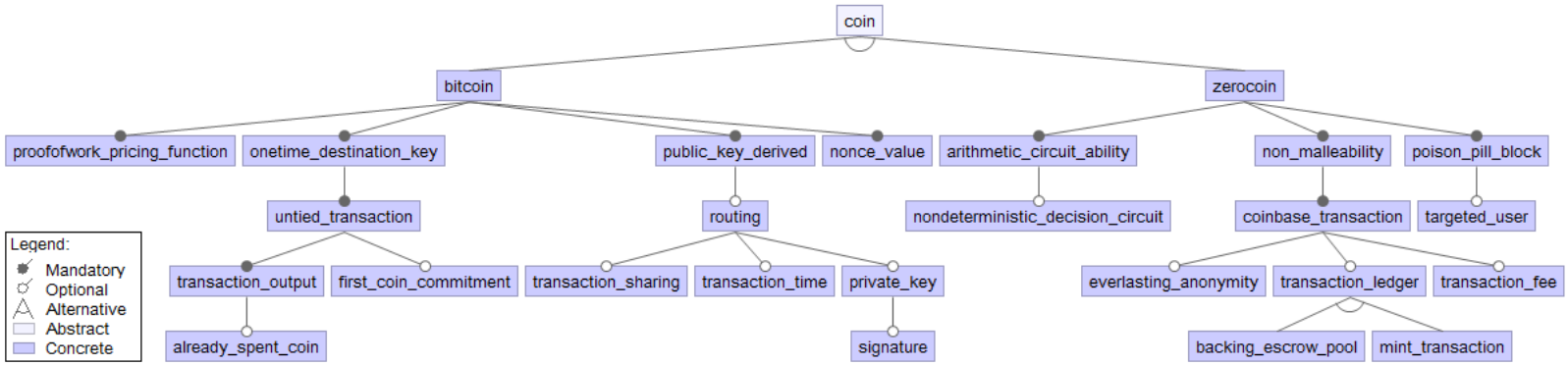

Figure 4: Cryptocurrency - FeatureX FM (manually created in FeatureIDE).

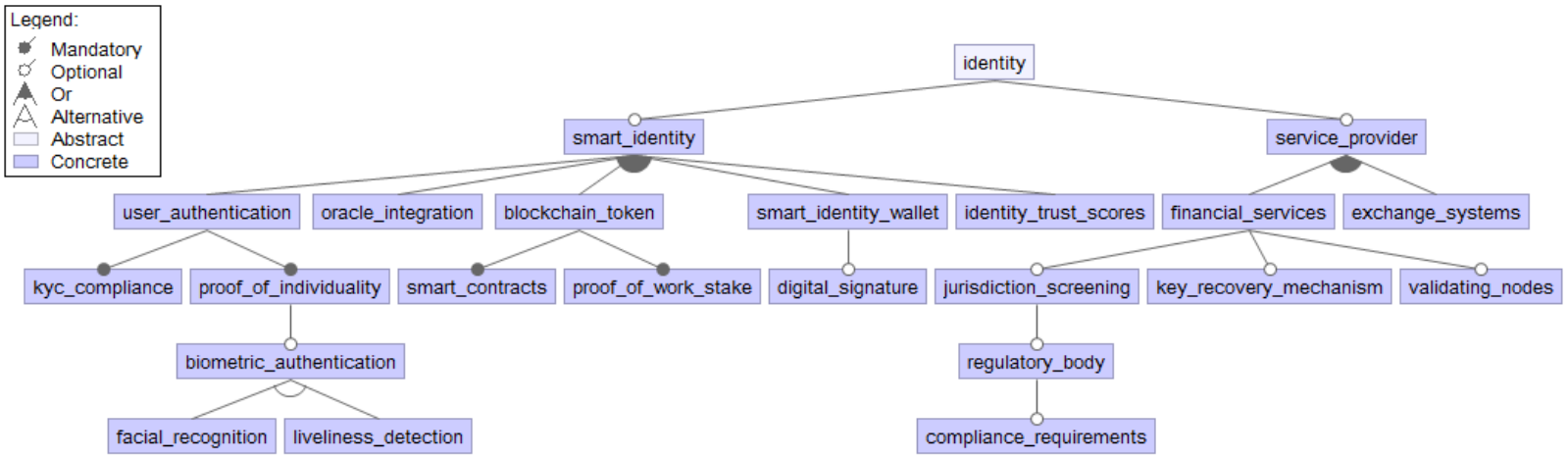

Figure 5: Identity - benchmark FM (manually created in FeatureIDE).

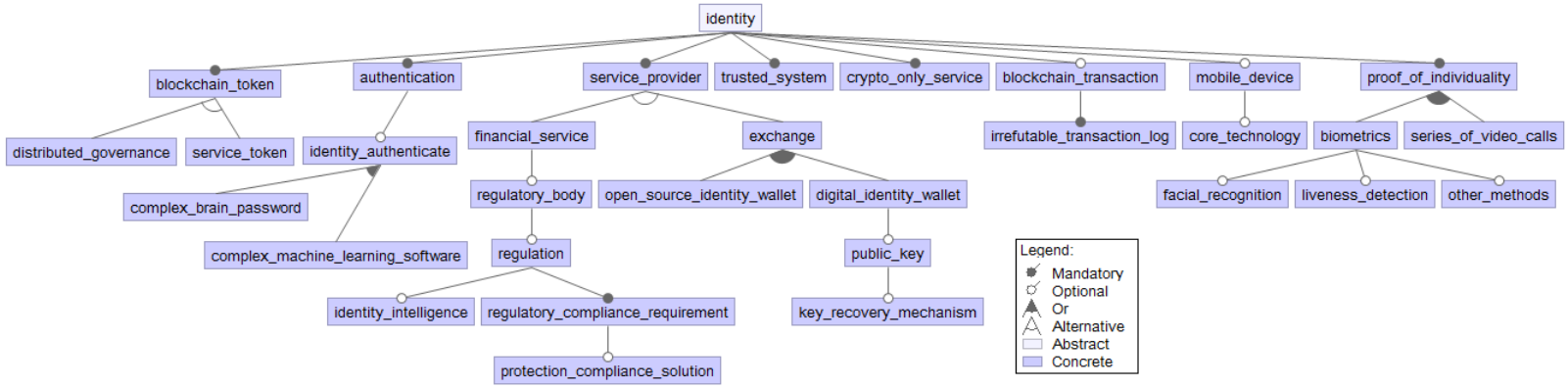

Figure 6: Identity - FeatureX FM (manually created in FeatureIDE).

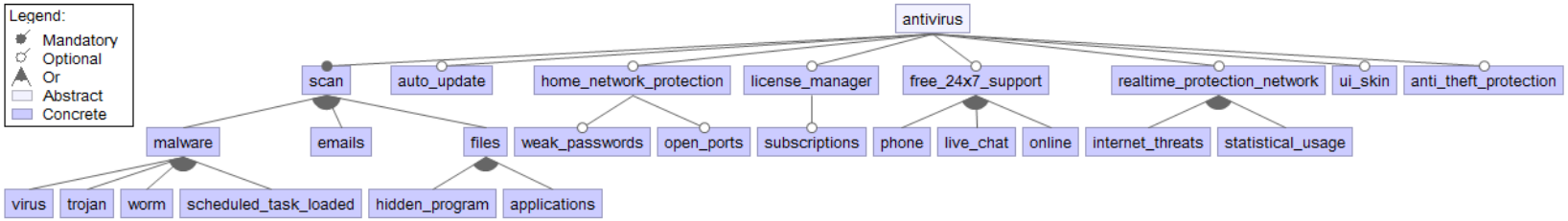

Figure 7: Antivirus - benchmark FM (manually created in FeatureIDE).

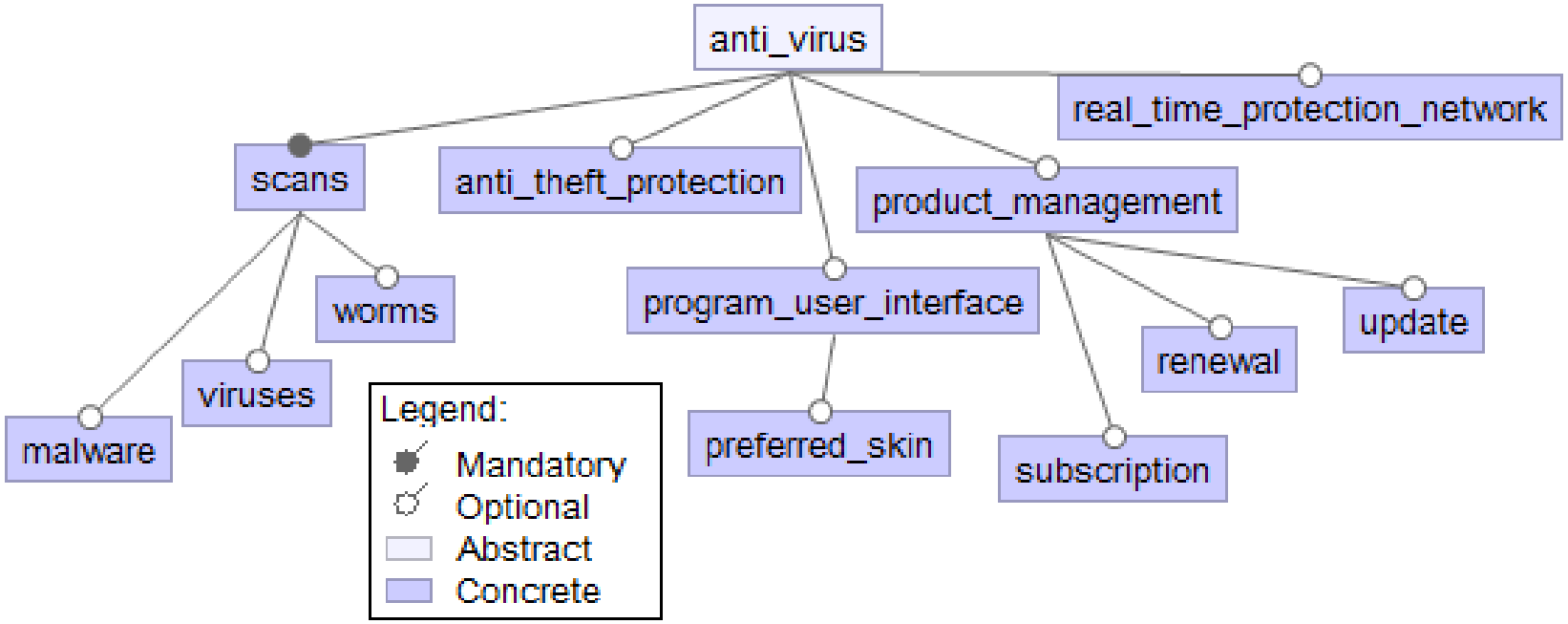

Figure 8: Antivirus - FeatureX FM (manually created in FeatureIDE).

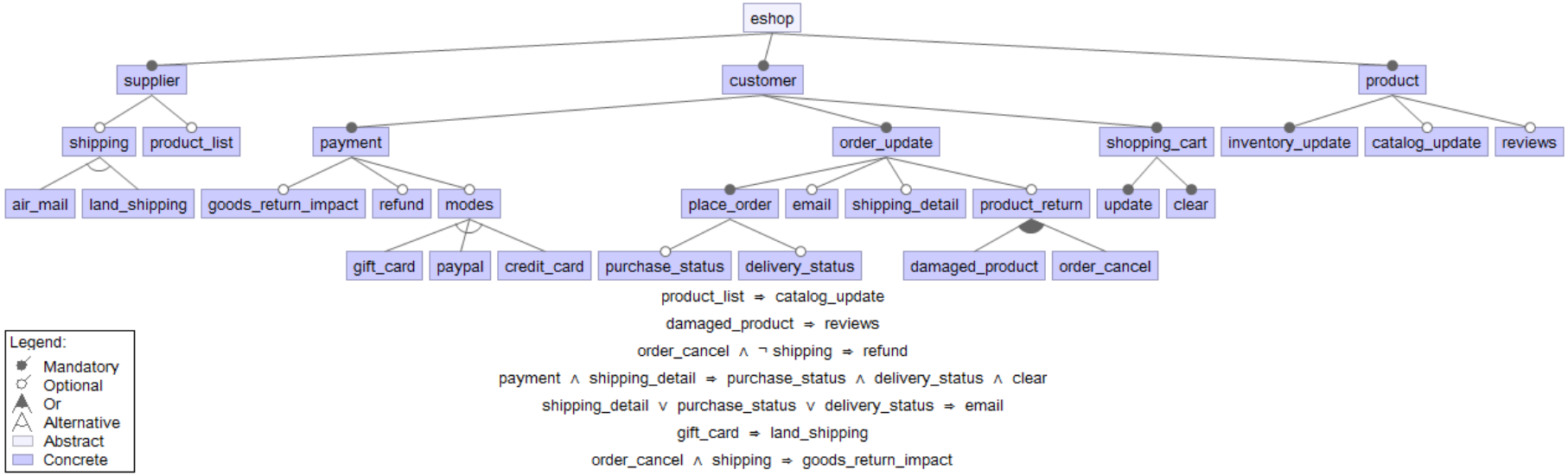

Figure 9: E-shop - benchmark FM (manually created in FeatureIDE).

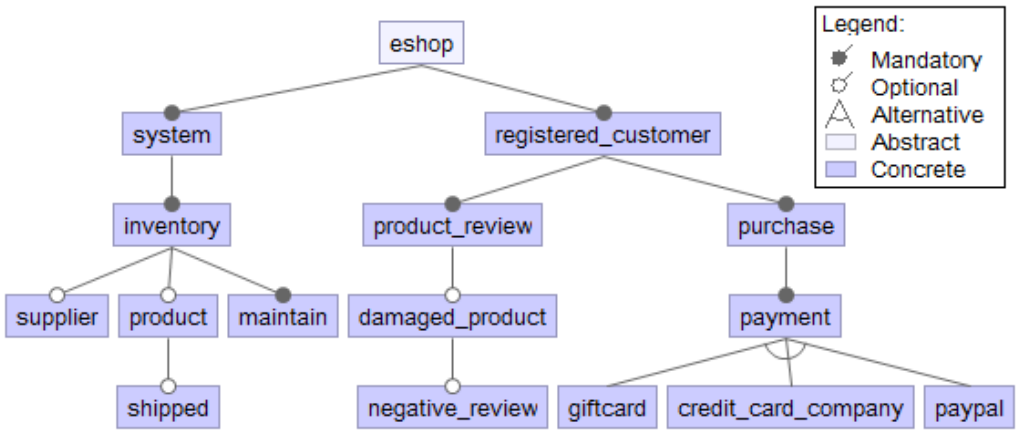

Figure 10: E-shop - FeatureX FM (manually created in FeatureIDE).

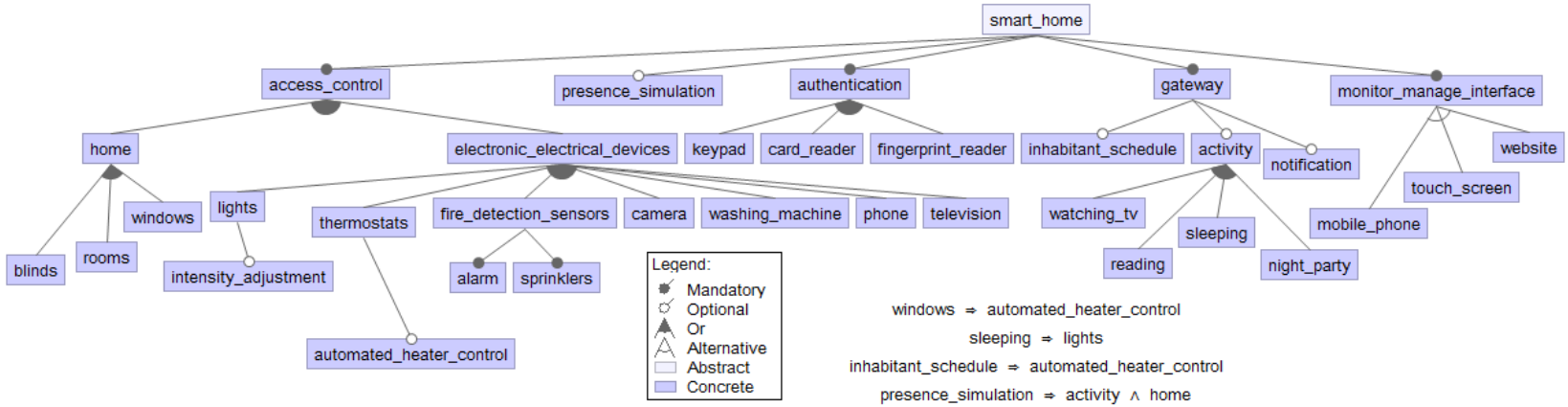

Figure 11: Smart Home - benchmark FM (manually created in FeatureIDE).

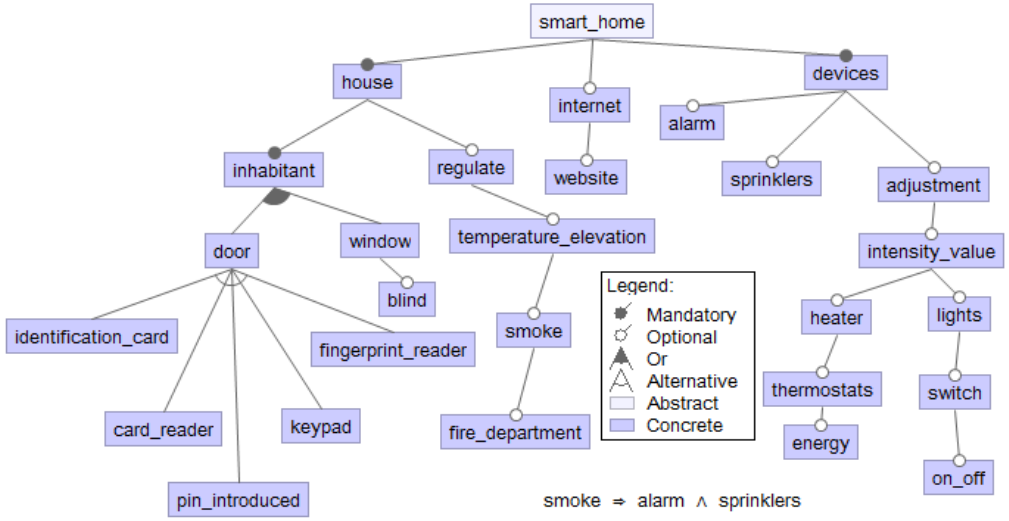

Figure 12: Smart Home - FeatureX FM (manually created in FeatureIDE).

1 FMs from literature

1.1 E-shop

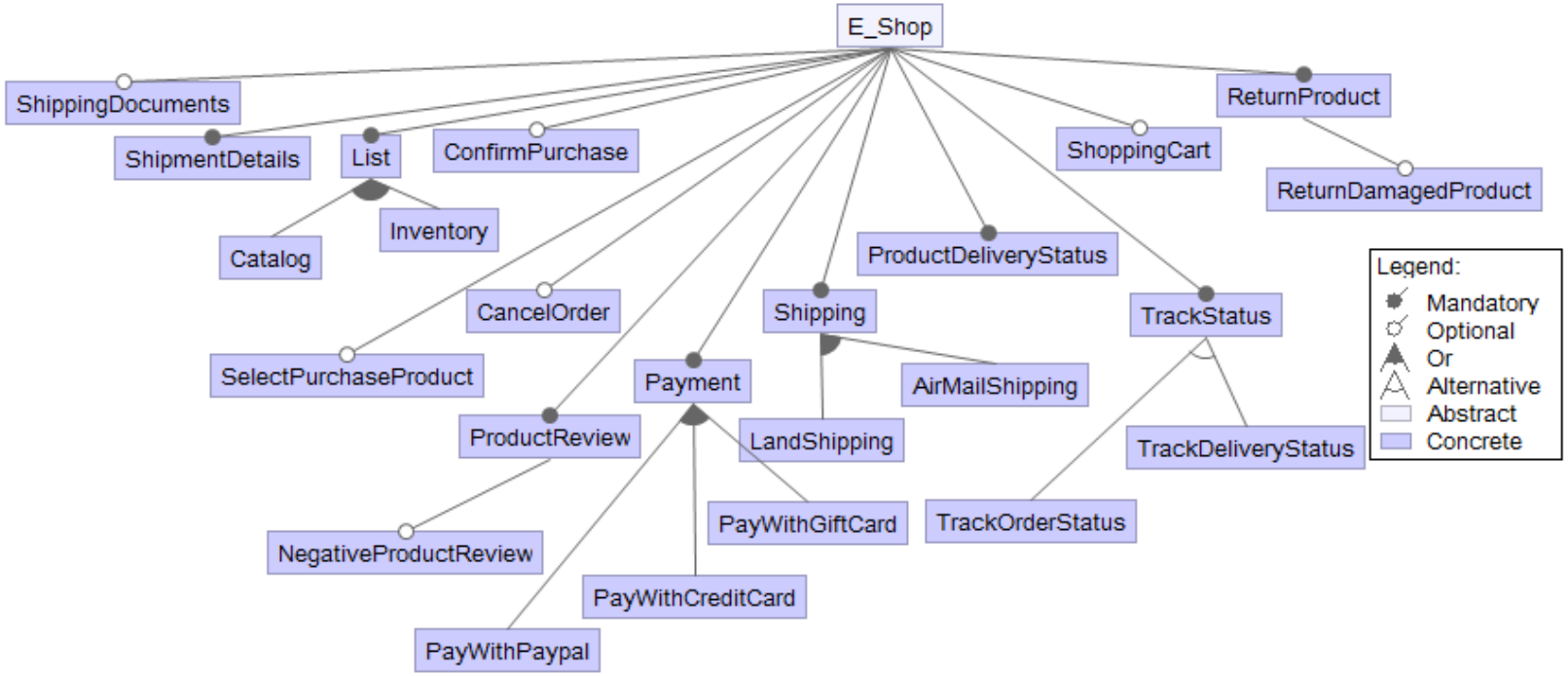

Figure 13: E-shop - FM from literature (manually created in FeatureIDE).

1.2 Smart home

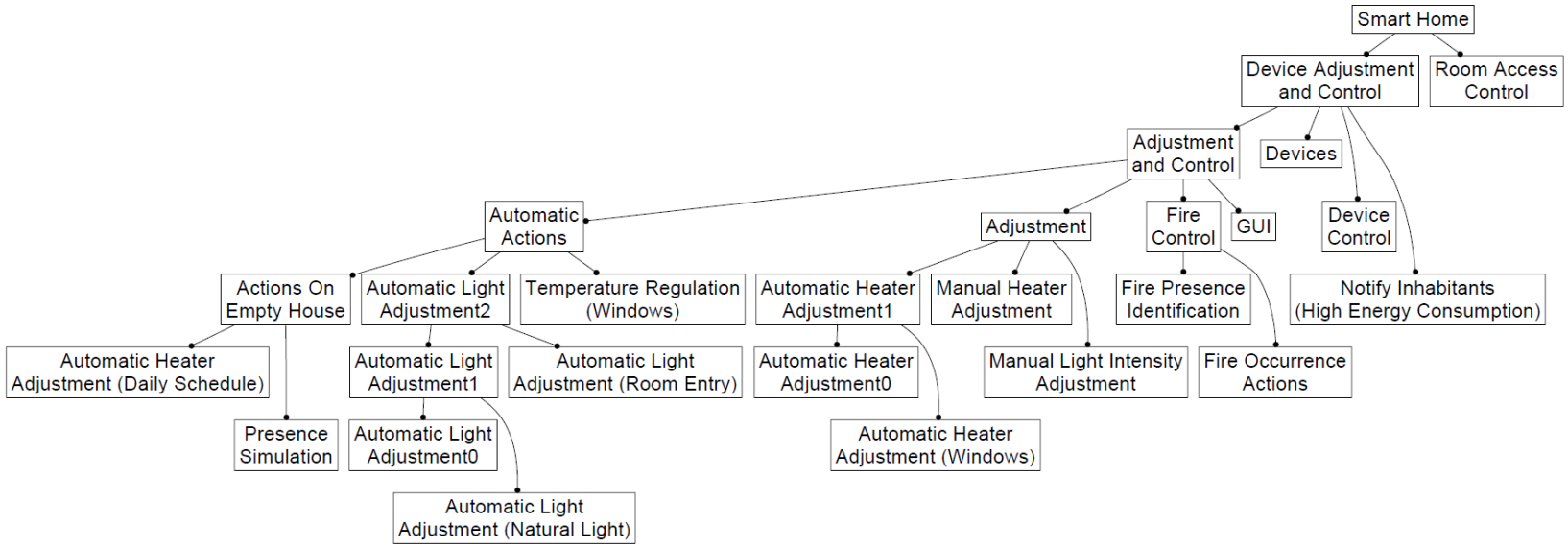

Figure 14: Smart Home - FM from literature.

1.3 Anti-virus

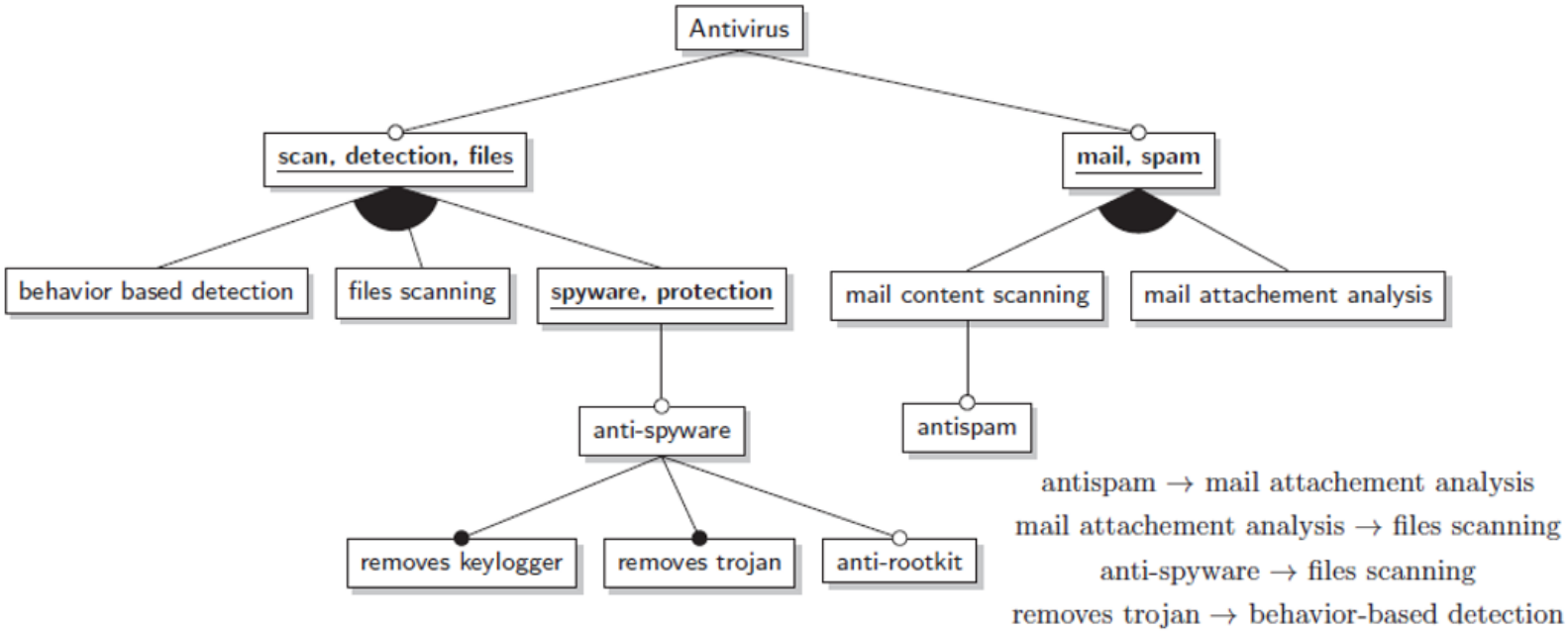

Figure 15: Anti-virus - FM from literature.

2 Manual evaluation of FeatureX models with benchmark models by domain engineers

2.1 Legend used for relationship type

Table 1: Types of relationships among features.

One-to-one mapping	One-to-many mapping
[**M**] MANDATORY	[**A**] AND
[**O**] OPTIONAL	[**R**] OR
[**E**] EXCLUDES	[**X**] ALTERNATIVE/XOR
[**I**] REQUIRE/IMPLIES	

2.2 Crash management product line

Table 2: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(bcrash, vehicle_management)	(bcrash, vehicle_management)	✓	✓	100% **M**
(bcrash, fire_station_coordinator)	(bcrash, fire_station_coordinator)	✓	✓	100% **M**
(bcrash, police_station_coordinator)	(bcrash, police_station_coordinator)	✓	✓	100% **M**
(bcrash, crisis_multiplicity)	(bcrash, crisis_multiplicity)	✓	✓	100% **O**
(bcrash, messaging_infrastructure)	(bcrash, messaging_infrastructure)	✓	✓	100% **M**
(vehicle_management, vehicle_communication_protocol)	(vehicle_management, communication_protocol)	✓	✓	60% **O**
(vehicle_management, coordinated_route_plan)	(vehicle_management, coordinated_route_plan)	✓	✓	60% **O**
(police_station_coordinator, lead_coordinator)	-	×	×	-
(fire_station_coordinator, wired_connection)	-	×	×	-
(fire_station_coordinator, citizen_vehicle)	(fire_station_coordinator, citizen_vehicle)	✓	✓	60% **O**
(crisis_multiplicity, manage_traffice)	(vehicle_management, manage_traffice)	✓	×	80% **O**
(messaging_infrastructure, send_and_receive_messages)	(messaging_infrastructure, send_and_receive_messages)	×	✓	90% **M**
(messaging_infrastructure, security_mechanisms)	(messaging_infrastructure, security_mechanisms)	✓	×	90% **M**
(security_mechanisms, confidentiality)	(security_mechanisms, confidentiality)	✓	✓	90% **R**
(security_mechanisms, encrypted)	(security_mechanisms, encrypted)	✓	✓	90% **R**
(security_mechanisms, non_encrypted_communications)	(security_mechanisms, non_encrypted)	✓	✓	90% **R**
(security_mechanisms, user_authentication)	(security_mechanisms, user_authentication)	✓	✓	90% **R**

2.3 Cryptocurrency product line

Table 3: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(coin, bitcoin)	(coin, bitcoin)	✓	✓	90% **X**
(coin, zerocoin)	(coin, zerocoin)	✓	✓	90% **X**
(bitcoin, proofofwork_pricing_function)	(bitcoin, proofofwork_pricing_function)	✓	✓	90% **M**
(bitcoin, onetime_destination_key)	(bitcoin, onetime_destination_key)	✓	✓	90% **M**
(bitcoin, pulic_key_derived)	-	×	×	-
(bitcoin, nonce_value)	(bitcoin, nonce_value)	✓	✓	80% **M**
(zerocoin, arithmetic_circuit_ability)	(zerocoin, arithmetic_circuit_ability)	✓	✓	80% **M**
(zerocoin, non_malleability)	(zerocoin, non_malleability)	✓	✓	80% **M**
(zerocoin, poison_pill_block)	(zerocoin, poison_pill_block)	✓	✓	70% **M**
(onetime_destination_key, united_transaction)	-	×	×	-
(united_transaction, transaction_output)	-	×	×	-
(united_transaction, first_coin_commitment)	-	×	×	-
(transaction_output, already_spent_coin)	-	×	×	-
(public_key_derived, routing)	(public_key, routing)	×	✓	70% **M**
(routing, transaction_sharing)	(routing, transaction_sharing)	✓	✓	90% **O**
(routing, transaction_time)	-	×	×	-
(routing, private_key)	(routing, private_key)	×	✓	80% **M**
(private_key, signature)	(private_key, signature)	×	✓	90% **M**
(arithmetic_circuit_ability, non_deterministic_decision_circuit)	(arithmetic_circuit_ability, non_deterministic_decision_circuit)	✓	✓	100% **O**
(non_malleability, coinbase_transaction)	(transaction, non_malleability)	✓	×	100% **M**
(coinbase_transaction, everlasting_anonymity)	(coinbase_transaction, anonymity)	×	✓	90% **M**
(coinbase_transaction, transaction_ledger)	(coinbase_transaction, transaction_ledger)	✓	✓	80% **O**
(coinbase_transaction, transaction_fee)	(coinbase_transaction, transaction_fee)	×	✓	100% **M**
(transaction_ledger, backing_escrow_pool)	-	×	×	-
(transaction_ledger, mint_transaction)	-	×	×	-

2.4 Identity software product line

Table 4: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(identity, blockchain)	(identity, blockchain)	✓	✓	100% **M**
(identity, authentication)	(identity, authentication)	✓	✓	100% **M**
(identity, service_provider)	-	×	×	-
(identity, trusted_system)	(identity, trusted_system)	✓	✓	100% **M**
(identity, crypto_only_service)	-	×	×	-
(identity, blockchain_transaction)	(identity, blockchain_transaction)	✓	✓	80% **O**
(identity, mobile_device)	(identity, mobile_device)	✓	✓	100% **O**
(identity, proof_of_individuality)	(identity, proof_of_individuality)	✓	✓	100% **M**
(blockchain_token, blockchain_governance)	(blockchain_token, blockchain_governance)	✓	✓	70% **X**
(blockchain_token, service_token)	(blockchain_token, service_token)	✓	✓	70% **X**
(authentication, identity_authenticate)	(authentication, identity_authenticate)	×	✓	100% **M**
(service_provider, financial_service)	(service_provider, financial_service)	✓	✓	50% **X**
(service_provider, exchange)	(service_provider, exchange)	✓	✓	70% **X**
(blockchain_transaction, irrefutable_transaction_log)	(blockchain_transaction, irrefutable_transaction_log)	✓	✓	100% **M**
(mobile_device, core_technology)	-	×	×	-
(proof_of_individuality, biometrics)	(proof_of_individuality, biometrics)	✓	✓	100% **R**
(proof_of_individuality, series_of_video_calls)	(proof_of_individuality, series_of_video_calls)	✓	✓	50% **R**
(biometrics, facial_recognition)	(biometrics, facial_recognition)	✓	✓	100% **O**
(biometrics, liveness_detection)	(biometrics, liveness_detection)	✓	✓	100% **O**
(biometrics, other_methods)	-	×	×	-
(identity_authenticate, complex_brain_password)	(identity_authenticate, complex_brain_password)	✓	✓	80% **R**
(identity_authenticate, complex_machine_learning_software)	(identity_authenticate, machine_learning_software)	✓	✓	60% **R**
(financial_service, regulatory_body)	-	×	×	-
(exchange, open_source_identity_wallet)	(exchange, open_source_identity_wallet)	✓	✓	80% **R**
(exchange, digital_identity_wallet)	(exchange, digital_identity_wallet)	✓	✓	90% **R**
(digital_identity_wallet, public_key)	(digital_identity_wallet, public_key)	×	✓	90% **M**
(public_key, key_recovery_mechanism)	(public_key, key_recovery_mechanism)	✓	✓	100% **O**
(regulatory_body, regulation)	-	×	×	-
(regulation, identity_intelligence)	(regulation, identity_intelligence)	×	✓	80% **O**
(regulation, regulatory_compliance_requirement)	-	×	×	-
(regulatory_compliance_requirement, protection_compliance_solution)	-	×	×	-

2.5 Anti-virus product line

Table 5: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(anti_virus, scans)	(anti_virus, scans)	✓	✓	100% **M**
(anti_virus, anti_theft_protection)	(anti_virus, anti_theft_protection)	×	✓	100% **M**
(anti_virus, product_management)	(anti_virus, product_management)	✓	✓	100% **O**
(anti_virus, real_time_protection_network)	(anti_virus, real_time_protection_network)	✓	✓	100% **O**
(anti_virus, program_user_interface)	(anti_virus, program_user_interface)	✓	✓	80% **O**
(scans, malware)	(scans, malware)	×	✓	60% **R**
(scans, viruses)	(scans, viruses)	×	✓	60% **R**
(scans, worms)	(scans, worms)	×	✓	60% **R**
(program_user_interface, preferred_skin)	(program_user_interface, preferred_skin)	✓	✓	70% **O**
(product_management, subscription)	(product_management, subscription)	✓	✓	100% **O**
(product_management, renewal)	(product_management, renewal)	✓	✓	100% **O**
(product_management, update)	(product_management, update)	✓	✓	100% **O**

2.6 E-shop product line

Table 6: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(eshop, system)	-	×	×	-
(eshop, registered_customer)	(eshop, customer)	✓	✓	100% **M**
(system, inventory)	(eshop, inventory)	✓	✓	100% **M**
(registered_customer, product_review)	(registered_customer, product_review)	×	✓	90% **O**
(registered_customer, purchase)	(customer, purchase)	✓	✓	90% **M**
(inventory, supplier)	(inventory, supplier)	×	✓	70% **M**
(inventory, product)	(inventory, product)	×	✓	70% **M**
(inventory, maintain)	(inventory, maintain)	✓	✓	70% **M**
(product_review, damaged_product)	-	×	×	-
(damaged_product, negative_review)	-	×	×	-
(purchase, payment)	(purchase, payment)	✓	✓	90% **M**
(payment, gift_card)	(payment, gift_card)	✓	✓	100% **A**
(payment, credit_card_company)	(payment, credit_card_company)	✓	✓	100% **A**
(payment, paypal)	(payment, paypal)	✓	✓	100% **A**

2.7 Smart home product line

Table 7: FeatureX

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(smart_home, house)	-	×	×	-
(smart_home, internet)	-	×	×	-
(smart_home, devices)	(smart_home, devices)	✓	✓	100% **M**
(devices, alarm)	(devices, alarm)	×	✓	90% **A**
(devices, sprinklers)	(devices, sprinklers)	×	✓	90% **A**
(devices, adjustment)	-	×	×	-
(adjustment, intensity_value)	(devices, adjust_intensity_value)	✓	✓	100% **O**
(intensity_value, heater)	(devices, heater)	×	✓	60% **R**
(intensity_value, lights)	(devices, lights)	×	✓	60% **R**
(heater, thermostats)	-	×	×	-
(thermostats, energy)	-	×	×	-
(lights, switch)	-	×	×	-
(switch, on_off)	-	×	×	-
(internet, website)	-	×	×	-
(house, inhabitant)	-	×	×	-
(house, regulate)	(house, regulate)	×	✓	60% **M**
(inhabitant, door)	-	×	×	-
(inhabitant, window)	-	×	×	-
(window, blind)	-	×	×	-
(door, identification_card)	(door, identification_card)	✓	✓	70% **X**
(door, card_reader)	(door, card_reader)	✓	✓	80% **X**
(door, pin_introduced)	(door, pin_introduced)	✓	✓	80% **X**
(door, keypad)	(door, keypad)	✓	✓	80% **X**
(door, fingerprint_reader)	(door, fingerprint_reader)	✓	✓	80% **X**
(regulate, temperature_elevation)	(regulate, temperature_elevation)	✓	✓	100% **O**
(temperature_elevation, smoke)	(temperature_elevation, smoke)	✓	✓	100% **O**
(smoke, fire_department)	(smoke, fire_department)	✓	✓	100% **O**

3 Manual evaluation of FM generated by methods used in literature

Table 8: E-shop

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(E_shop, ShipmentDetails)	(E_shop, ShipmentDetails)	✓	✓	90% **M**
(E_shop, ShippingDocuments)	-	×	×	-
(E_shop, List)	-	×	×	-
(E_shop, ConfirmPurchase)	(E_shop, ConfirmPurchase)	×	✓	90% **M**
(E_shop, SelectPurchaseProduct)	(E_shop, PurchaseProduct)	×	✓	90% **M**
(E_shop, CancelOrder)	(E_shop, CancelOrder)	✓	✓	90% **O**
(E_shop, ProductReview)	(E_shop, ProductReview)	×	✓	90% **O**
(E_shop, Payment)	(E_shop, Payment)	✓	✓	80% **M**
(E_shop, Shipping)	(E_shop, Shipping)	✓	✓	80% **M**
(E_shop, ProductDeliveryStatus)	-	×	×	-
(E_shop, ShoppingCart)	(E_shop, ShoppingCart)	×	✓	60% **R**
(E_shop, TrackStatus)	(E_shop, TrackStatus)	×	✓	60% **R**
(E_shop, ReturnProduct)	(E_shop, ReturnProduct)	×	✓	60% **R**
(List, Catalog)	-	×	×	-
(List, Inventory)	-	×	×	-
(ProductReview, NegativeProductReview)	-	×	×	-
(Payment, PayWithCreditCard)	(Payment, CreditCard)	×	✓	90% **X**
(Payment, PayWithGiftCard)	(Payment, GiftCard)	×	✓	90% **X**
(Payment, PayWithPaypal)	(Payment, Paypal)	×	✓	90% **X**
(Shipping, LandShipping)	(Shipping, Land)	✓	✓	90% **X**
(Shipping, AirMailShipping)	(Shipping, AirMail)	✓	✓	90% **X**
(TrackStatus, TrackOrderStatus)	(TrackStatus, OrderStatus)	×	✓	90% **O**
(TrackStatus, TrackDeliveryStatus)	(TrackStatus, DeliveryStatus)	×	✓	90% **O**
(ReturnProduct, ReturnDamagedProduct)	(ReturnProduct, DamagedProduct)	✓	✓	90% **O**

Table 9: Smart home

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(Smart Home, Device Adjustment and Control)	(Smart Home, Device Adjustment and Control)	✓	✓	100% **M**
(Smart Home, Room Access Control)	(Smart Home, Room Access Control)	×	✓	100% **O**
(Device Adjustment and Control, Adjustment and Control)	-	×	×	-
(Device Adjustment and Control, Devices)	-	×	×	-
(Device Adjustment and Control, Device Control)	-	×	×	-
(Device Adjustment and Control, Notify Inhabitants (High Energy Consumption))	-	×	×	-
(Adjustment and Control, Automatic Actions)	(Adjustment and Control, Automatic Actions)	×	✓	60% **O**
(Adjustment and Control, Fire Control)	(Adjustment and Control, Fire Control)	×	✓	60% **O**
(Adjustment and Control, Adjustment)	-	×	×	-
(Adjustment and Control, GUI)	(Adjustment and Control, GUI)	×	✓	60% **O**
(Automatic Actions, Actions On Empty House)	(Automatic Actions, On Empty House)	×	✓	80% **O**
(Automatic Actions, Automatic Light Adjustment2)	(Automatic Actions, Light Adjustment)	×	✓	80% **O**
(Automatic Actions, Temperature Regulation (Windows))	(Automatic Actions, Temperature Regulation)	×	✓	90% **O**
(Adjustment, Automatic Heater Adjustment)	(Automatic Actions, Heater Adjustment)	×	✓	60% **O**
(Adjustment, Manual Light Intensity Adjustment)	(Device Adjustment and Control, Manual Light Intensity Adjustment)	✓	✓	90% **O**
(Adjustment, Manual Heater Adjustment)	(Device Adjustment and Control, Manual Heater Adjustment)	×	✓	90% **O**
(Fire Control, Fire Presence Identification)	(Fire Control, Fire Presence Identification)	✓	✓	80% **M**
(Fire Control, Fire Occurrence Actions)	(Fire Control, Fire Occurrence Actions)	✓	✓	80% **M**
(Actions On Empty House, Automatic Heater Adjustment (Daily Schedule))	-	×	×	-
(Actions On Empty House, Presence Simulation)	(On Empty House, Presence Simulation)	×	✓	90% **O**
(Automatic Light Adjustment2, Automatic Light Adjustment1)	-	×	×	-
(Automatic Light Adjustment2, Automatic Light Adjustment(Room Entry)	-	×	×	-
(Automatic Light Adjustment1, Automatic Light Adjustment0)	-	×	×	-
(Automatic Light Adjustment1, Automatic Light Adjustment (Windows)	-	×	×	-

Table 10: Anti-virus

Candidate feature pair	Corrected name (if needed)	Relationship exists?	Correct direction?	Confidence and type
(Antivirus, scan/detection/files)	(Antivirus, scan/detection/files)	×	✓	80% **M**
(Antivirus, mail/spam)	(Antivirus, mail/spam)	✓	✓	80% **O**
(scan/detection/files, behavior based detection)	-	×	×	-
(scan/detection/files, files scanning)	(scan, files)	✓	✓	80% **R**
(scan/detection/files, anti-spyware/protection)	(detection, spyware_protection)	✓	✓	80% **R**
(anti-spyware/protection , removes keylogger)	(spyware_protection , removes keylogger)	✓	✓	90% **M**
(anti-spyware/protection , removes trojan)	(spyware_protection , removes trojan)	×	✓	90% **O**
(anti-spyware/protection , anti-rootkit)	(spyware_protection , anti-rootkit)	✓	✓	90% **O**
(mail/spam, mail content scanning)	(mail_spam, content scanning)	✓	✓	90% **R**
(mail/spam, mail attachement analysis)	(mail_spam, attachement analysis)	✓	✓	90% **R**
(mail content scanning, antispam)	(content scanning, antispam)	✓	✓	90% **O**
(spyware/protection,anti-spyware)	(spyware/protection,anti-spyware)	×	✓	90% **M**
(antispam, mail attachment analysis)	(antispam, mail attachment analysis)	✓	✓	60% **I**
(mail attachment analysis, files scanning)	(mail attachment analysis, files scanning)	✓	✓	60% **I**
(anti-spyware, file scanning)	(anti-spyware, file scanning)	✓	✓	60% **I**
(removes trojan, behavior-based detection)	(removes trojan, behavior-based detection)	✓	✓	60% **I**