The "Vehicle Insurance - UServ Product Derby" Challenge, Dec - 2014
A Solution Based on a 3D Relational Rule Base
by Leonid Nisenboym

1. The Challenge Description

This challenge is about a solution to computerized processing of auto insurance applications. In detail requirements, procedure and business rules are discussed in the UServ Product Derby Case Study [1].

There are three entities that are involved in auto insurance application processing: clients, related cars and drivers. The goal of the application processing is to analyze associated risk indicators and apply results to calculate the insurance premium amount a client should pay annually.

2. How this Challenge is Addressed?

To address this challenge a business rules technology which is the part of the relational knowledge-driven decisioning framework was applied. This framework includes a set of knowledge structures, their models and methods of representation and reasoning. Its distinctive feature is a relational view at knowledge.

In my previous publication on DMCommunity website [2] the two-dimension relational rule base structure was employed to address the "Pay-As-You-Go" Challenge. This structure is built on two components: rule number and rule conditions. Such structure, however, is not sufficient to address the auto insurance application challenge. Therefore a three-dimension relational rule base structure is applied in this case by adding the third dimensional component - business rule category.

3. Solution Development

3.1. Data Glossary

As mentioned above there are three entities involved in auto insurance application processing. Each entity in its turn is defined by three groups of attributes: base attributes representing source data, decision attributes representing decisions and explanation attributes providing explanation of each decision.

Case Study includes scenarios representing different configurations of the source data for clients. The two major of them are employed below for demonstration purposes.

3.1.1. Base Attributes

In Figures 1 to 3 below base attributes for clients, drivers and cars as well as their values are shown.

Client ID	Application Date	Client Descr	Client Segment	Long Term Client
1	12/31/2014	Sara Klaus	"Preferred"	"FALSE"
2	1/2/2015	Shane Meno	"Elite"	"TRUE"

Fig. 1. Client Base Attributes and Source Data

Client ID	Driver Name	Driver Gender	Marital Status	State	Driver Age	Convicted Of DUI	Qty Moving Violations Last Two Years	Qty Accidents	Driver Has Driving Training Certificate From School	Driver Has Training From Licensed Driver Training Company	Driver Has Taken Senior Citizen Driver Refresher Course
1	Sara Klaus	"Female"	"Single"	"AR"	38	"No"	1	0	"FALSE"	"FALSE"	"FALSE"
1	Spencer Klaus	"Male"	"Single"	"AR"	17	"No"	0	0	"TRUE"	"FALSE"	"FALSE"
2	Shane Meno	"Male"	"Single"	"CA"	21	"No"	3	2	"TRUE"	"FALSE"	"FALSE"

Fig. 2. Driver Base Attributes and Source Data

Client ID	Car Name	Car Year	Car Price	Convertible	On High Theft Probability List	Car Type	Driver AirBag	Front Passenger Airbag	Side Passenger Airbag	Side Panel AirBag	Roll Bar	Alarm System	Uninsured Motorist Coverage Included
1	Honda Odyssey	2005	39000	"FALSE"	"FALSE"	"Luxury"	"TRUE"	"TRUE"	"TRUE"	"TRUE"	"TRUE"	"TRUE"	"TRUE"
1	Toyota Camry	2002	12000	"FALSE"	"FALSE"	"Compact"	"TRUE"	"TRUE"	"FALSE"	"FALSE"	"FALSE"	"FALSE"	"TRUE"
2	VW Bug	1965	1500	"TRUE"	"TRUE"	"Compact"	"FALSE"	"FALSE"	"FALSE"	"FALSE"	"FALSE"	"FALSE"	"FALSE"

Fig.3. Car Base Attributes and Source Data

3.1.2. Decision Attributes

Here are descriptions of decision attributes:

1. Clients: d_ClientAutoPremium , d_ClientDriverPremium , d_ClientBasePremium, d_ClientTotalPremium , d_ClientEligibilityScore, d_ClientEligibilityRating.
2. Drivers: d_DriverAgeRating, d_DriverTrainingCertRating, d_DriverEligibilityRating, d_DrivingRecordRating, d_DriverEligibilityScore .
3. Cars: d_CarTheftRating, d_OccupantInjuryRating, d_AutoEligibilityRating, d_BasePremium, d_AutoPremiumSummary, d_AutoDiscount, d_AutoPremiumFinal.

3.1.3. Explanation Attributes

The names of explanation attributes are formed using the name of the corresponding decision attribute with addition of the suffix "_Explanation". For example, the name of explanation attribute related to decision attribute "d_ClientAutoPremium" will be "d_ClientAutoPremium_Explanation".

3.2. Business Rule Categories

Each business rule category represents a group of business rules which perform a certain application processing function (such as analysis of risk indicators, calculating premiums, etc.). They are listed below in Fig. 4.

Decisioning about	Rule Category Code	Rule Category Description	Data Source	Decision Field Name	Destination Table
Cars	11	Car Theft Rating	tCars	d_CarTheftRating	
Cars	12	Occupant Injury Rating	tCars	d_OccupantInjuryRating	
Cars	13	Auto Eligibility Rating	tCars	d_AutoEligibilityRating	
Cars	14	Auto Base Premium	tCars	d_BasePremium	
Cars	15	Auto Premium Summary	tCars	d_AutoPremiumSummary	
Cars	16	Auto Discount	tCars	d_AutoDiscount	
Cars	17	Auto Premium Final	tCars	d_AutoPremiumFinal	
Drivers	21	Driver Age Rating	tDrivers	d_DriverAgeRating	
Drivers	22	Driver Training CertRating	tDrivers	d_DriverTrainingCertRating	
Drivers	23	Driver Eligibility Rating	tDrivers	d_DriverEligibilityRating	
Drivers	24	Driving Record Rating	tDrivers	d_DrivingRecordRating	
Drivers	25	Driver Premium	tDrivers	d_DriverPremium	
Clients	31	Client Eligibility Score Auto	tCars	d_ClientEligibilityScore	tClients
Clients	32	Client Eligibility Score Drivers	tDrivers	d_ClientEligibilityScore	tClients
Clients	33	Adjust Client Eligibility Score	tClients	d_ClientEligibilityScore	
Clients	34	Client Eligibility Rating	tClients	d_ClientEligibilityRating	
Clients	35	Client Auto Premium	tCars	d_ClientAutoPremium	tClients
Clients	36	Client Base Premium	tCars	d_ClientBasePremium	tClients
Clients	37	Client Driver Premium	tDrivers	d_ClientDriverPremium	tClients
Clients	38	Client Total Premium	tClients	d_ClientTotalPremium	
Clients	39	Adjust Total Premium Based on Client Segment	tClients	d_ClientTotalPremium	
Clients	40	Adjust Total Premium Based on Client Base Premium	tClients	d_ClientTotalPremium	

Fig. 4. Business Rule Categories.

The first column in this list defines three consecutive steps in application processing: decisioning about cars, drivers and a client. Then rule category code and its description columns go. Then goes the name of the data source followed by the names of the decision field and destination table where the reasoning result should be placed. If the destination table name is missing, it means that the destination and the source tables are the same.

Business rules by itself exemplify one of the forms of knowledge. Business rule categories represent knowledge about business rules and therefore demonstrate a meta knowledge component of the 3D relational rule base.

3.3. Decision Logic

The diagram in Fig. 5 shows decision logic; in particular, the process of transformation of data source attributes into decision attributes and finally answering the question: what is the amount of the auto insurance premium the client should pay. In presentation of each decision attribute a business rule category that generates it is shown in brackets.

3.4. Business Rules

The list of business rules is shown in Appendix 1. Each business rule comprised of 5 fields. The first field represents business rule category which defines the business function the related rule play. Then the rule number goes which uniquely identifies business rules in the rule base. It followed by list of conditions that represents premises of the rule. The conclusion part of the rule consists of two fields: operation and decision. Operations define the process

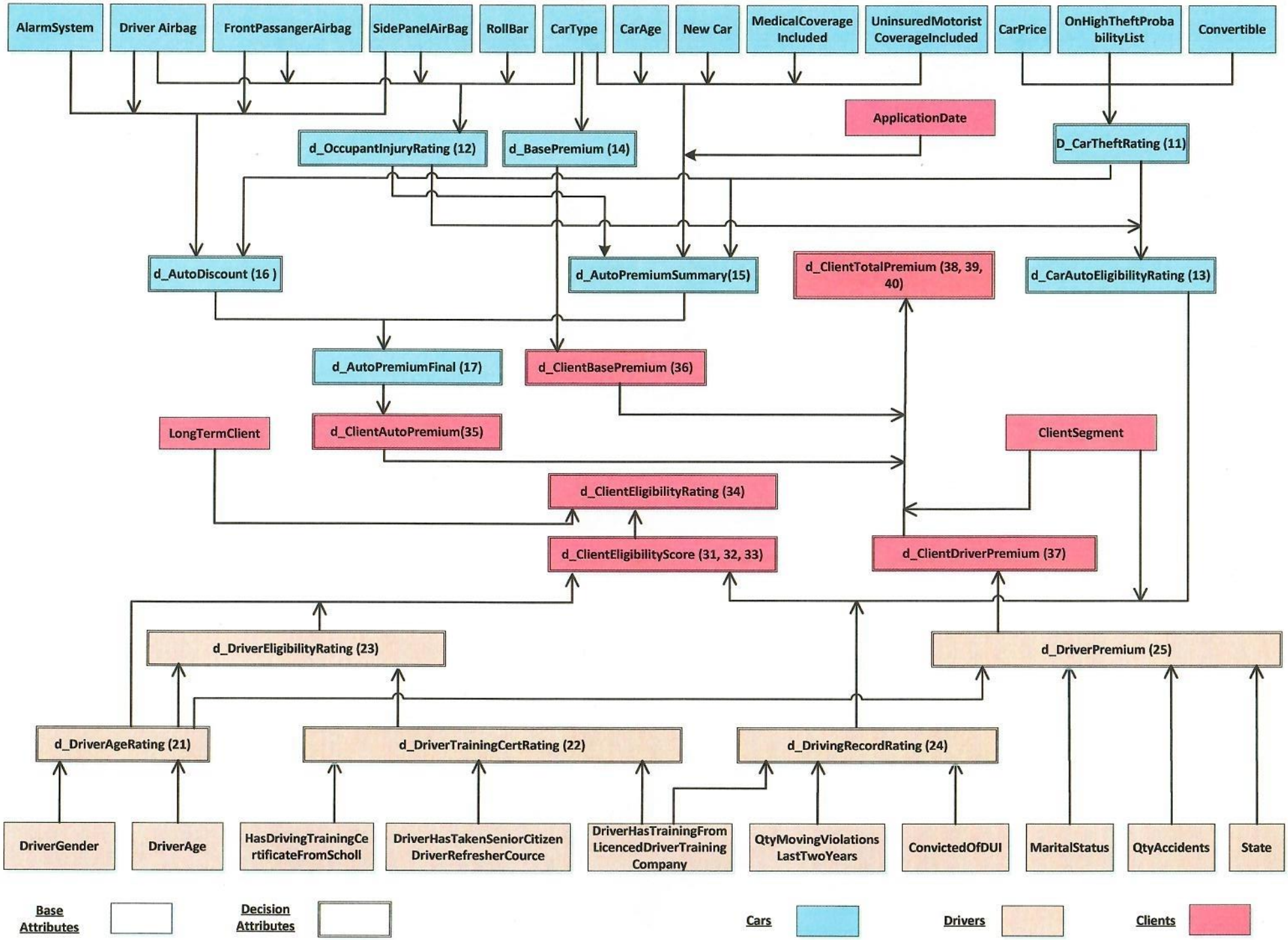

Fig. 5. Decision Logic

the rule decision should go through before placing it in the destination table. There are four such operations: "=", "+", "Calc" and "Calc+". The "=" operation assigns the rule decision value to the decision field in the destination table. The "+" operation adds the rule decision value to a value already existed in the decision field in the destination table. The "Calc" operation is calculating the value of expression defined in the rule decision field. This value then placed in the decision field of destination table. Finally, the "Calc+" operation first evaluates the value of expression in the rule's decision field and then adds this value to a value already existing in the destination decision field.

3.5. Development Platform

The solution described above demonstrates a 3-dimensional approach to relational rule base design which is applicable for development of complex decisioning applications.

This solution was developed on the basis of Microsoft® Access and Microsoft® Visual Basic. It represents an integrated data and business rule-driven software product. Such products can be made in any programming environment containing RDMS.

3.6. Test Results

The test results are shown in Fig. 6 and Fig.7. For each client a report is generated to show the auto insurance application processing results. Each report includes all related decisions made during application processing. Each decision is followed by explanation in the form of reference to related business rules.

References

1. UServ Product Derby Case Study. http://ai.ia.agh.edu.pl/wiki/ media/hekate:2005 product derby.pdf, 2014.
2. L. Nisenboym. Relational Rule Base: A Solution for "Pay-As-You-Go Pricing" Challenge, May-2020, https://dmcommunity.files.wordpress.com/2020/10/challenge2020may.leonidnisenboym.pdf, 2020

Results of Auto Insurance Application Processing

Client: Sara Klaus

Client Related Decisions

Client Auto Premium		Client Driver Premium		Client Base Premium		Client Total Premium		Client Eligibility Score		Client Eligibility Rating	
Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation
2,330.50	CAP-1 (1353), CAP-1 (977.5)	300	CDP-1 (0), CDP-1 (300)	750.00	CBP-1 (500), CBP-1 (250)	2,380.50	CTP-1 (2630.5), ATPS-1 (-250)	-50.00	CESA-3 (0), CESA-3 (0), CESD-4 (0), CESD-4 (0), ACES-1 (-50)	"Eligible Client"	CER-2

Car Related Decisions

Car Name	Base Premium		Auto Premium Summary		Auto Discount		Auto Premium Final		Car Theft Rating		Occupant Injury Rating		Auto Eligibility Rating	
	Value, $	Explanation	Value, $	Explanation	Value, %	Explanation	Value, $	Explanation	Value	Explanation	Value	Explanation	Value	Explanation
Honda Odyssey	500.00	ABP-3	1,650	APS-12 (500), APS-16 (250), APS-17 (300), APS-18 (600)	18.00	AD-3 (18)	1,353.00	APF-1	"Moderate"	CTR-4	"Low"	OIR-4	"Eligible"	AER-4
Toyota Camry	250.00	ABP-1	1,150	APS-10 (250), APS-17 (300), APS-18 (600)	15.00	AD-2 (15)	977.50	APF-1	"Low"	CTR-5	"Moderate"	OIR-3	"Eligible"	AER-4

Driver Related Decisions

Driver Name	Driver Age Rating		Driver Training Certification Rating		Driver Eligibility Rating		Driving Record Rating		Driver Premium	
	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value, $	Explanation
Sara Klaus	"Regular Driver"	DAR-5	"Driver Does Not Have Training Certification"	DTC-4	"Eligible Driver"	DER-3	"Low Risk Driver"	DRR-4	0	DP-6 (0), DP-8 (0)
Spencer Klaus	"Young Driver"	DAR-1	"Driver Has Training Certification"	DTC-1	"Eligible Driver"	DER-1	"Low Risk Driver"	DRR-4	300	DP-4 (300), DP-8 (0)

Fig. 6. Testing Results. Client: Sara Claus

Results of Auto Insurance Application Processing

Client: Shane Meno

Client Related Decisions

Client Auto Premium		Client Driver Premium		Client Base Premium		Client Total Premium		Client Eligibility Score		Client Eligibility Rating	
Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation
1,750.00	CAP-1 (1750)	1,020	CDP-1 (1020)	250.00	CBP-1 (250)	2,270.00	CTP-1 (2770), ATPS-2 (-500)	-50.00	CESA-2 (50), CESD-4 (0), ACES-2 (-100)	"Eligible Client"	CER-2

Car Related Decisions

Car Name	Base Premium		Auto Premium Summary		Auto Discount		Auto Premium Final		Car Theft Rating		Occupant Injury Rating		Auto Eligibility Rating	
	Value, $	Explanation	Value, $	Explanation	Value, %	Explanation	Value, $	Explanation	Value	Explanation	Value	Explanation	Value	Explanation
VW Bug	250.00	ABP-1	1,750	APS-10 (250), APS-19 (1000), APS-21 (500)	0.00	AD-5	1,750.00	APF-1	"HIGH"	CTR-3	"Extremly High"	OIR-5	"Provisional"	AER-3

Driver Related Decisions

Driver Name	Driver Age Rating		Driver Training Certification Rating		Driver Eligibility Rating		Driving Record Rating		Driver Premium	
	Value	Explanation	Value	Explanation	Value	Explanation	Value	Explanation	Value, $	Explanation
Shane Meno	"Young Driver"	DAR-1	"Driver Has Training Certification"	DTC-1	"Eligible Driver"	DER-1	"Low Risk Driver"	DRR-4	1020	DP-2 (720), DP-8 (300)

Fig. 7. Testing Results.Client: Shane Meno

Appendix 1. Business Rules

Rule Category Code	Rule Number	Condition1	Condition2	Condition3	Condition4	Operation	Decision
Car Theft Rating	CTR-1	Convertible = "TRUE"				=	"HIGH"
Car Theft Rating	CTR-2	CarPrice > 45000				=	"HIGH"
Car Theft Rating	CTR-3	OnHighTheftProbabilityList = "TRUE"				=	"HIGH"
Car Theft Rating	CTR-4	OnHighTheftProbabilityList = "FALSE"	CarPrice >= 20000	CarPrice <= 45000		=	"Moderate"
Car Theft Rating	CTR-5	OnHighTheftProbabilityList = "FALSE"	CarPrice < 20000			=	"Low"
Occupant Injury Rating	OIR-1	DriverAirBag = "FALSE"	FrontPassangerAirbag = "FALSE"	SidePanelAirBag = "FALSE"		=	"Extremely High"
Occupant Injury Rating	OIR-2	DriverAirBag = "TRUE"	FrontPassangerAirbag = "FALSE"	SidePanelAirBag = "FALSE"		=	"HIGH"
Occupant Injury Rating	OIR-3	DriverAirBag = "TRUE"	FrontPassangerAirbag = "TRUE"			=	"Moderate"
Occupant Injury Rating	OIR-4	DriverAirBag = "TRUE"	FrontPassangerAirbag = "TRUE"	SidePanelAirBag = "TRUE"		=	"Low"
Occupant Injury Rating	OIR-5	Convertible = "TRUE"	RollBar = "FALSE"			=	"Extremly High"
Auto Eligibility Rating	AER-1	d_OccupantInjuryRating = "ExtremlyHigh"				=	"Not Eligible"
Auto Eligibility Rating	AER-2	d_OccupantInjuryRating = "High"				=	"Provisional"
Auto Eligibility Rating	AER-3	d_CarTheftRating = "High"				=	"Provisional"
Auto Eligibility Rating	AER-4	d_OccupantInjuryRating <> "ExtremlyHigh"	d_OccupantInjuryRating <> "High"	d_CarTheftRating <> "High"		=	"Eligible"
Auto Base Premium	ABP-1	CarType = "Compact"				=	250
Auto Base Premium	ABP-2	CarType = "Sedan"				=	400
Auto Base Premium	ABP-3	CarType = "Luxury"				=	500
Auto Base Premium	ABP-4	CarType <> "Compact"	CarType <> "Sedan"	CarType <> "Luxury"		=	0
Auto Premium Summary	APS-10	CarType = "Compact"				+	250
Auto Premium Summary	APS-11	CarType = "Sedan"				+	400
Auto Premium Summary	APS-12	CarType = "Luxury"				+	500
Auto Premium Summary	APS-13	CarType <> "Compact"	CarType <> "Sedan"	CarType <> "Luxury"		+	0
Auto Premium Summary	APS-14	(ApplicationYear - CarYear) <= 0				+	400
Auto Premium Summary	APS-15	(ApplicationYear - CarYear) >= 1	(ApplicationYear - CarYear) < 5			+	300
Auto Premium Summary	APS-16	(ApplicationYear - CarYear) >= 5	(ApplicationYear - CarYear) < 10			+	250
Auto Premium Summary	APS-17	UninsuredMotoristCoverageIncluded = "TRUE"				+	300
Auto Premium Summary	APS-18	MedicalCoverageIncluded = "TRUE"				+	600

Appendix 1. Business Rules

Rule Category Code	Rule Number	Condition1	Condition2	Condition3	Condition4	Operation	Decision
Auto Premium Summary	APS-19	d_OccupantInjuryRating = "Extremly High"				+	1000
Auto Premium Summary	APS-20	d_OccupantInjuryRating = "High"				+	500
Auto Premium Summary	APS-21	d_CarTheftRating = "HIGH"				+	500
Auto Discount	AD-1	DriverAirBag = "TRUE"	FrontPassangerAirbag = "FALSE"	SidePassangerAirbag = "FALSE"		+	12
Auto Discount	AD-2	DriverAirBag = "TRUE"	FrontPassangerAirbag = "TRUE"	SidePassangerAirbag = "FALSE"		+	15
Auto Discount	AD-3	DriverAirBag = "TRUE"	FrontPassangerAirbag = "TRUE"	SidePassangerAirbag = "TRUE"		+	18
Auto Discount	AD-4	AlarmSystem = "TRUE"	d_CarTheftRating = "HIGH"			+	10
Auto Discount	AD-5	DriverAirBag = "FALSE"	FrontPassangerAirbag = "FALSE"	SidePassangerAirbag = "FALSE"	AlarmSystem = "FALSE"	=	0
Auto Premium Final	APF-1	d_AutoPremiumSummary >= 0	d_AutoDiscount >= 0			Calc	d_AutoPremiumSummary *(100 - d_AutoDiscount)/100
Driver Age Rating	DAR-1	DriverGender = "Male"	DriverAge < 25			=	"Young Driver"
Driver Age Rating	DAR-2	DriverGender = "Female"	DriverAge < 20			=	"Young Driver"
Driver Age Rating	DAR-3	DriverAge > 70				=	"Senior Driver"
Driver Age Rating	DAR-4	DriverGender = "Male"	DriverAge >=25	DriverAge <= 70		=	"Regular Driver"
Driver Age Rating	DAR-5	DriverGender = "Female"	DriverAge >=20	DriverAge <= 70		=	"Regular Driver"
Driver Training CertRating	DTC-1	DriverHasDrivingTrainingCertificateFromSchool = "TRUE"				=	"Driver Has Training Certification"
Driver Training CertRating	DTC-2	DriverHasTrainingFromLicencedDriverTrainingCompany = "TRUE"				=	"Driver Has Training Certification"
Driver Training CertRating	DTC-3	DriverHasTakenSeniorCitizenDriverRefresherCource="TRUE"				=	"Driver Has Training Certification"
Driver Training CertRating	DTC-4	DriverHasDrivingTrainingCertificateFromSchool <> "TRUE"	DriverHasTrainingFromLicencedDriverTrainingCompany <> "YES"	DriverHasTakenSeniorCitizenDriverRefresherCource <> "YES"		=	"Driver Does Not Have Training Certification"
Driver Eligibility Rating	DER-1	d_DriverAgeRating = "Young Driver"	d_DriverTrainingCertRating="Driver Has Training Certification"			=	"Eligible Driver"
Driver Eligibility Rating	DER-2	d_DriverAgeRating = "Senior Driver"	d_DriverTrainingCertRating="Driver Has Training Certification"			=	"Eligible Driver"
Driver Eligibility Rating	DER-3	d_DriverAgeRating = "Regular				=	"Eligible Driver"

Appendix 1. Business Rules

Rule Category Code	Rule Number	Condition1	Condition2	Condition3	Condition4	Operation	Decision
		Driver"					
Driver Eligibility Rating	DER-4	d_DriverAgeRating = "Young Driver"	d_DriverTrainingCertRating = "Driver Does Not Have Training Certification"			=	"Not Eligible Driver"
Driver Eligibility Rating	DER-5	d_DriverAgeRating = "Senior Driver"	d_DriverTrainingCertRating = "Driver Does Not Have Training Certification"			=	"Not Eligible Driver"
Driving Record Rating	DRR-1	ConvictedOfDUI = "YES"				=	"High Risk Driver"
Driving Record Rating	DRR-2	QtyAccidents > 2				=	"High Risk Driver"
Driving Record Rating	DRR-3	QtyMovingViolationsLastTwoYears > 3				=	"High Risk Driver"
Driving Record Rating	DRR-4	ConvictedOfDUI <> "YES"	QtyAccidents <= 2	QtyMovingViolationsLastTwoYears <= 3		=	"Low Risk Driver"
Driver Premium	DP-1	d_DriverAgeRating = "Young Driver"	MaritalStatus = "Married"	InStr('NY, CA, VA', State) > 0		+	700
Driver Premium	DP-2	d_DriverAgeRating = "Young Driver"	MaritalStatus = "Single"	InStr('NY, CA, VA', State) > 0		+	720
Driver Premium	DP-3	d_DriverAgeRating = "Young Driver"	MaritalStatus = "Married"	InStr('NY, CA, VA', State) = 0		+	300
Driver Premium	DP-4	d_DriverAgeRating = "Young Driver"	MaritalStatus = "Single"	InStr('NY, CA, VA', State) = 0		+	300
Driver Premium	DP-5	d_DriverAgeRating = "Senior Driver"	InStr('NY, CA, VA', State) > 0			+	500
Driver Premium	DP-6	d_DriverAgeRating= "Regular Driver"				+	0
Driver Premium	DP-7	d_DrivingRecordRating = "High Risk Driver"				+	1000
Driver Premium	DP-8	QtyAccidents >=0				Calc+	150*QtyAccidents
Client Eligibility Score Auto	CESA-1	d_AutoEligibilityRating = "Not Eligible"				+	100
Client Eligibility Score Auto	CESA-2	d_AutoEligibilityRating = "Provisional"				+	50
Client Eligibility Score Auto	CESA-3	d_AutoEligibilityRating = "Eligible"				+	0
Client Eligibility Score Drivers	CESD-1	d_DrivingRecordRating = "High Risk Driver"				+	100

Appendix 1. Business Rules

Rule Category Code	Rule Number	Condition1	Condition2	Condition3	Condition4	Operation	Decision
Client Eligibility Score Drivers	CESD-2	d_DriverAgeRating = "Young Driver"	d_DriverEligibilityRating <> "Eligible Driver"			+	30
Client Eligibility Score Drivers	CESD-3	d_DriverAgeRating = "Senior Driver"	d_DriverEligibilityRating <> "Eligible Driver"			+	20
Client Eligibility Score Drivers	CESD-4	d_DriverEligibilityRating = "Eligible Driver"				+	0
Adjust Client Eligibility Score	ACES-1	ClientSegment = "Preferred"				+	-50
Adjust Client Eligibility Score	ACES-2	ClientSegment = "Elite"				+	-100
Client Eligibility Rating	CER-1	LongTermClient = "TRUE"				=	"Eligible Client"
Client Eligibility Rating	CER-2	d_ClientEligibilityScore < 100				=	"Eligible Client"
Client Eligibility Rating	CER-3	d_ClientEligibilityScore >= 100	d_ClientEligibilityScore <= 250			=	"Client to be Reviewed"
Client Eligibility Rating	CER-4	d_ClientEligibilityScore > 250				=	"Not Eligible Client"
Client Auto Premium	CAP-1	d_AutoPremiumFinal >= 0				Calc+	d_AutoPremiumFinal
Client Base Premium	CBP-1	d_BasePremium >= 0				Calc+	d_BasePremium
Client Driver Premium	CDP-1	d_DriverPremium >= 0				Calc+	d_DriverPremium
Client Total Premium	CTP-1	d_ClientAutoPremium >= 0	d_ClientDriverPremium >= 0			Calc+	d_ClientAutoPremium + d_ClientDriverPremium
Adjust Total Premium Based on Client Segment	ATPS-1	ClientSegment = "Preferred"				+	-250
Adjust Total Premium Based on Client Segment	ATPS-2	ClientSegment = "Elite"				+	-500
Adjust Total Premium Based on Client Base Premium	ATPB-1	d_ClientTotalPremium < d_ClientBasePremium				=	d_BasePremium