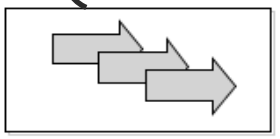
Decision Tables

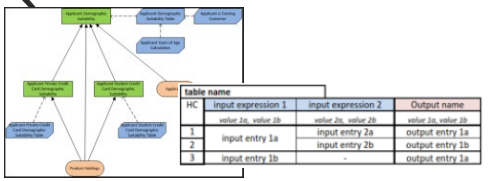
Process Logic

Business Logic

human experts

text


rules



decision model

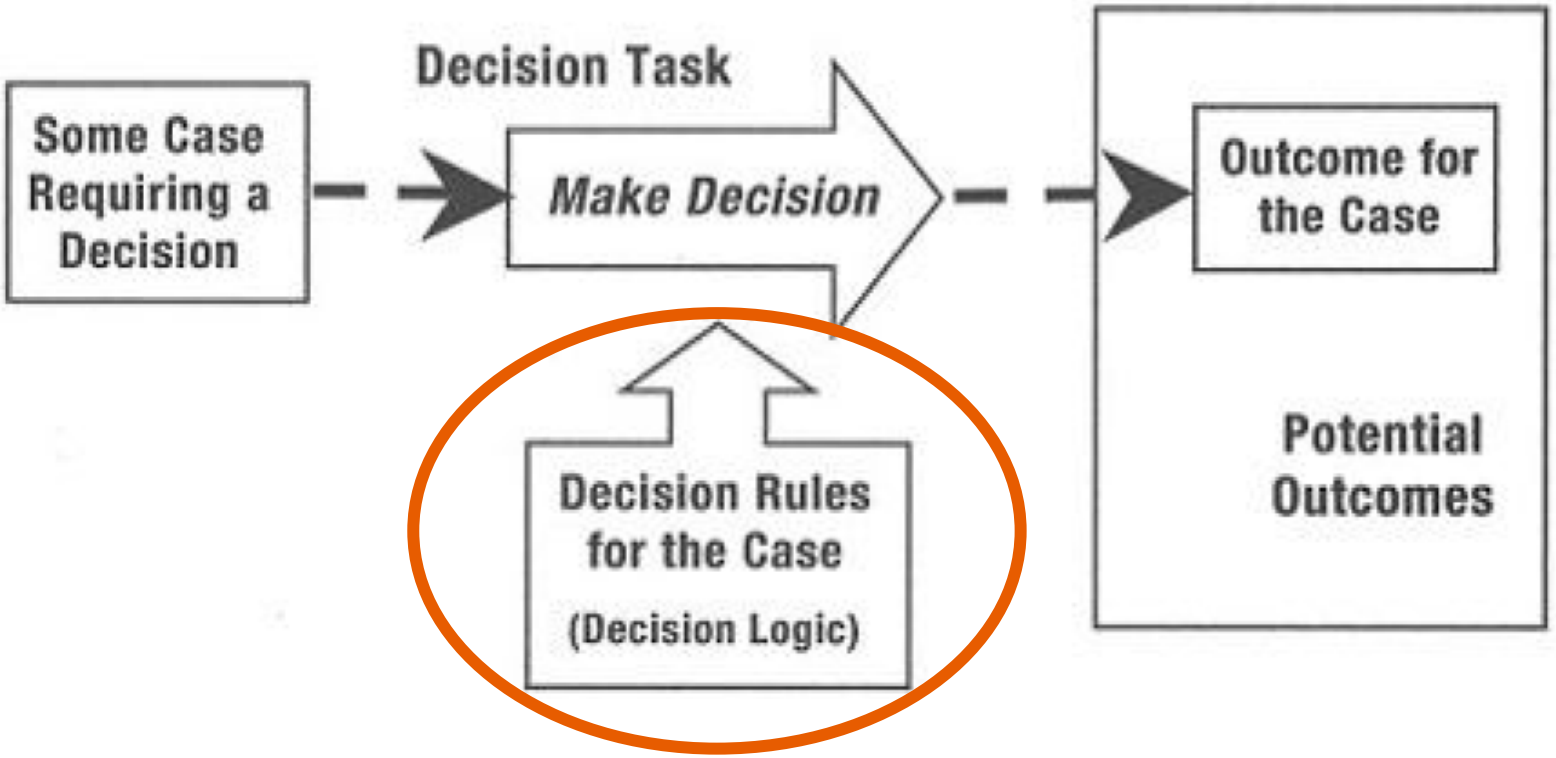
OBJECT MANAGEMENT GROUP

Decision Model and Notation

Beta1

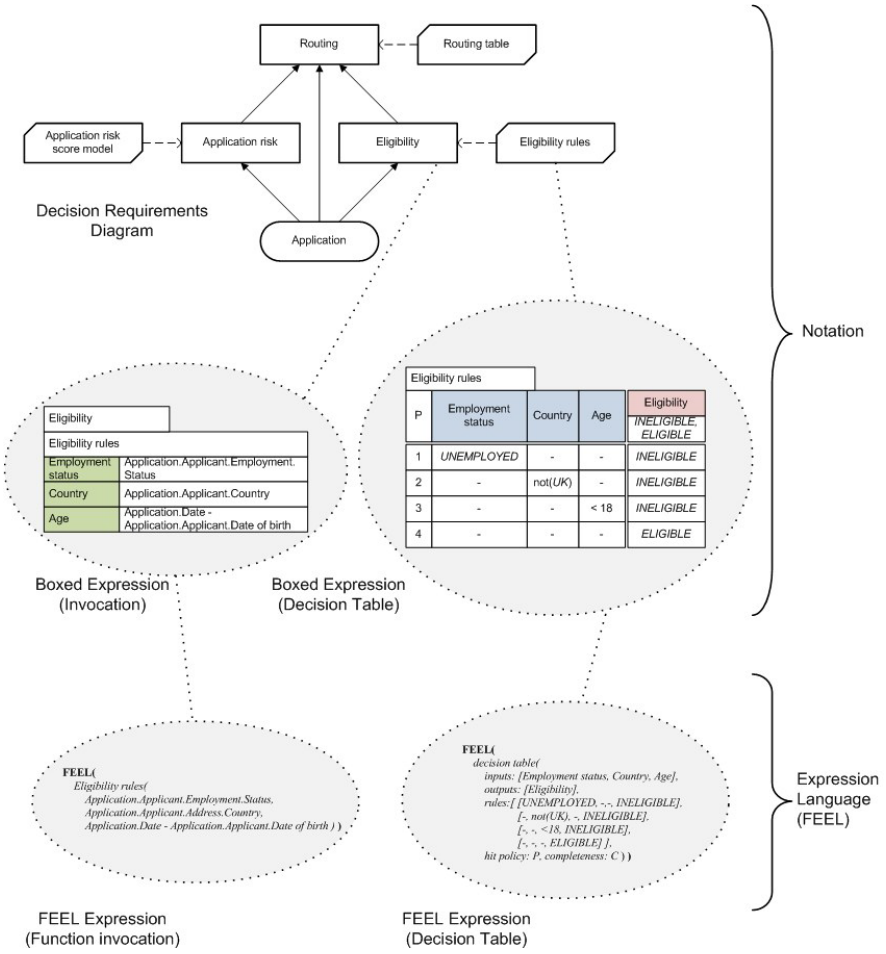
DECISION MODEL AND NOTATION (DMN)

Decision Logic and Decision Task



(Ross 2011, p. 152f)

Decision Model and Notation (DMN)



- The Decision Model and Notation is a new standard from the OMG
- It is currently published in its version 1.2
- Purpose of DMN: provide the constructs that are needed to model decision, so that organizational decision-making can be
  - readily depicted in diagrams
  - accurately defined by business analysts
  - (optionaly) automated

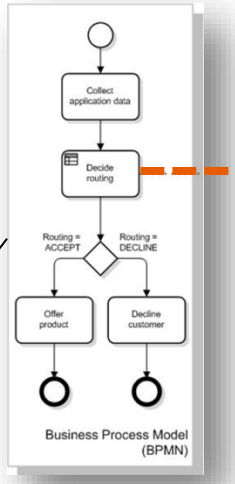
Main Concepts of DMN

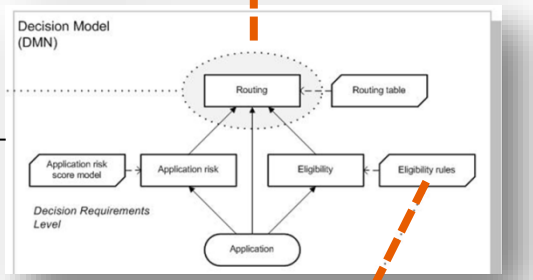
More details

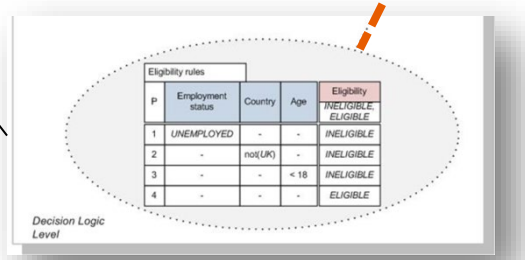
Business Process

Decision Requirements

Decision Logic



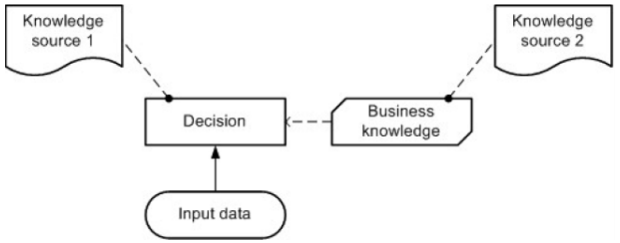


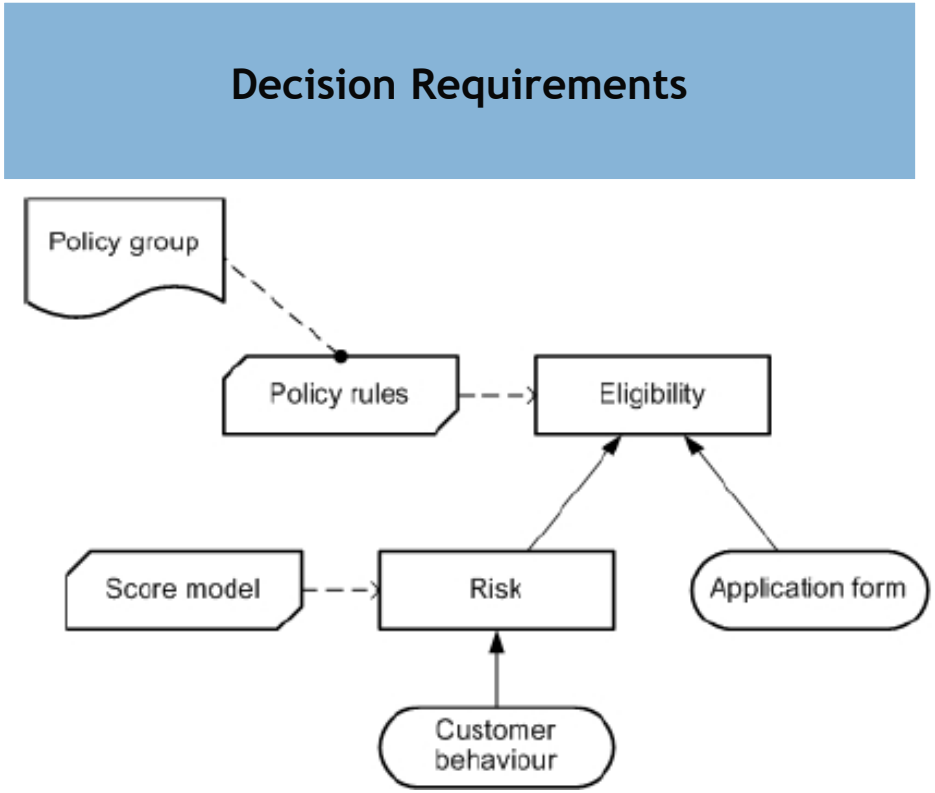


(Coenen 2013)

Main concepts – Decision Requirements Level

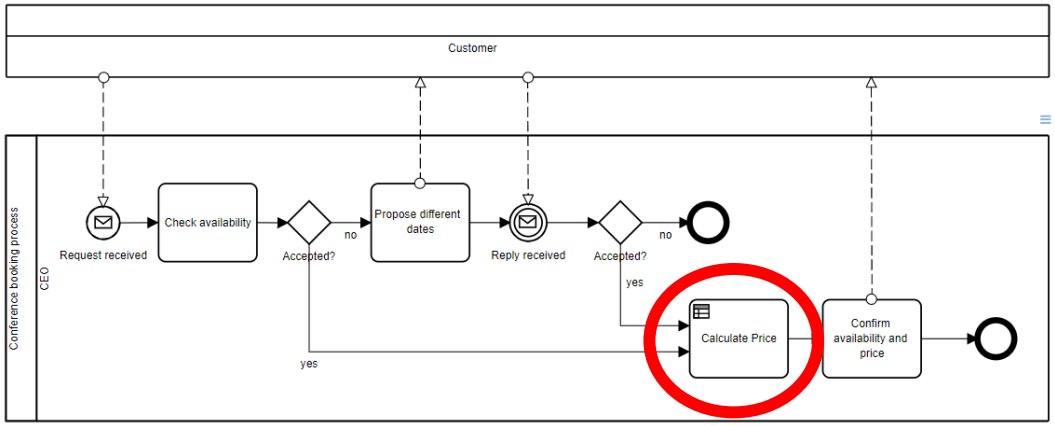
- Business decisions
- Business knowledge
- Sources of business knowledge
- Input Data



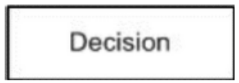
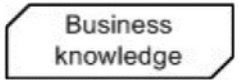
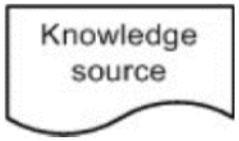
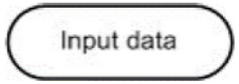


(Coenen 2013)

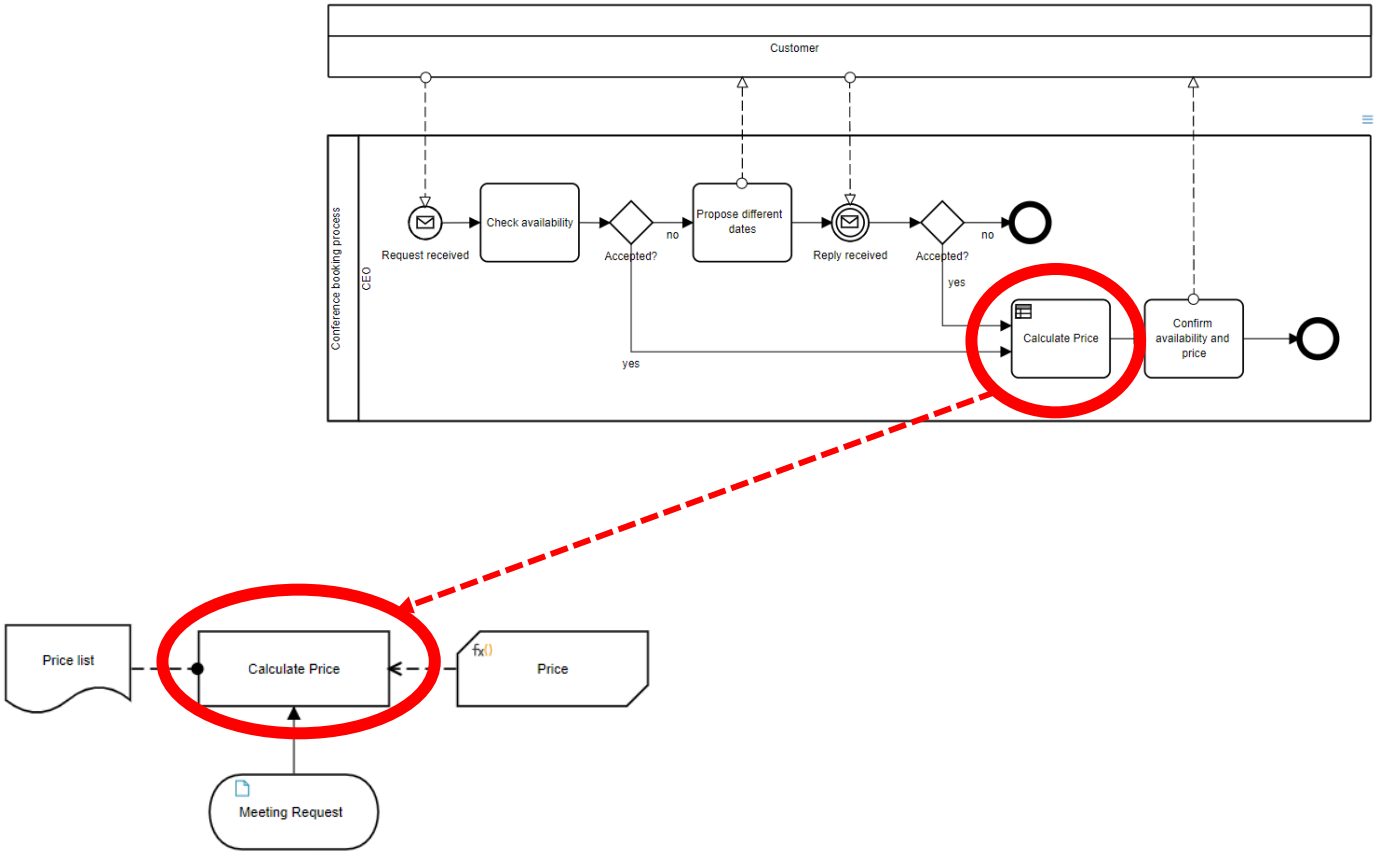
Decision Aware Representation of Booking Process with Price Calculation

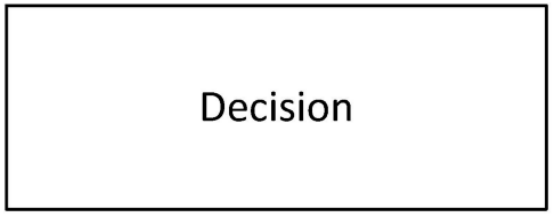


Constructs of a Decision Requirements Model

Construct	DMN Notation	Description
ELEMENTS		
Decision		The act of determining an output from a number of inputs, using decision logic which may reference one or more business knowledge models.
Business Knowledge Model		A function encapsulating business knowledge, in the form of business rules, decision table or analytic model. Some of the tool may not support this element. In such case the decision logic is directly linked to the Decision rather than the business knowledge model.
Knowledge Source		The authority for a business knowledge model or decision.
Input Data		Information used as an input by one or more decisions. It also denotes the parameters of a Business Knowledge Model.
REQUIREMENTS		
Information Requirement		Information - input data or decision output - required for a decision.
Knowledge Requirement		The invocation of a business knowledge model.
Authority Requirement		Showing the knowledge source of an element or the dependency of a knowledge source on input data.

Decision Aware Representation of Booking Process with Price Calculation





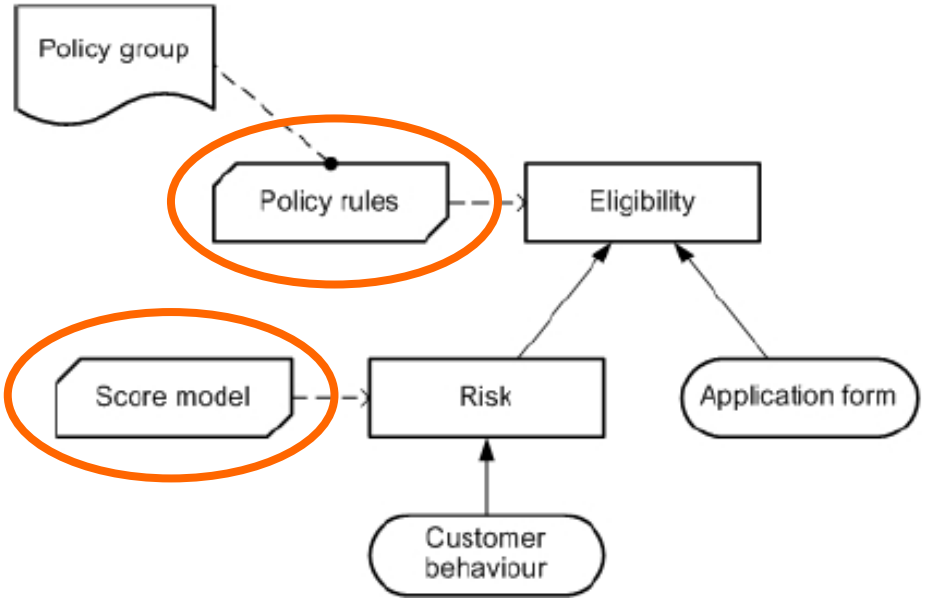
Decision

- A decision determines an output from a number of inputs by applying some decision logic.
- Two properties should be captured for every decision:
  - Question: A specific and detailed natural language statement that represents the decision in the form of a question.
  - Allowed Answers: A natural language description of the potential outcomes.
- Decisions can have reference to Decision Logic
- Decisions can be decomposed into sub-decisions.
  - Top level decisions can be thought of as selecting an answer from a range of possible answers.
  - Lower level decisions provide input to higher-level decisions.

Business Knowledge

Business Knowledge Models

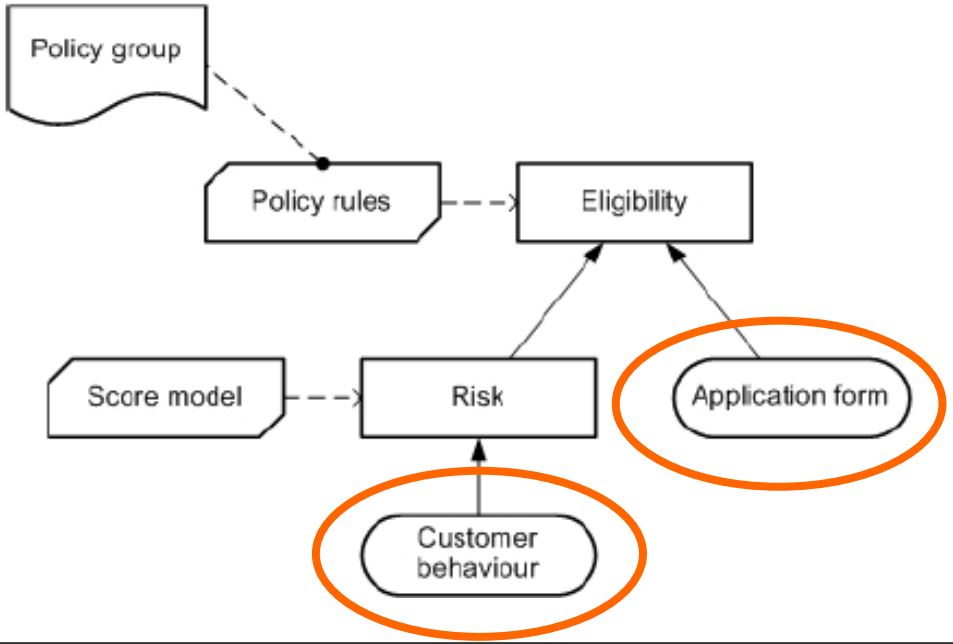
- Business knowledge models represent reusable decision logic.
- The decision logic might be
  - a decision table,
  - a decision tree,
  - a set of business rules,
  - an analytic model.

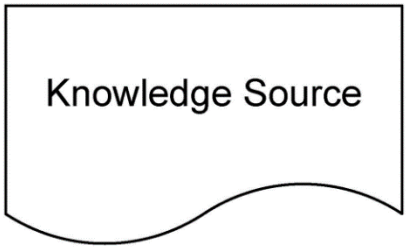


Input Data

Input Data

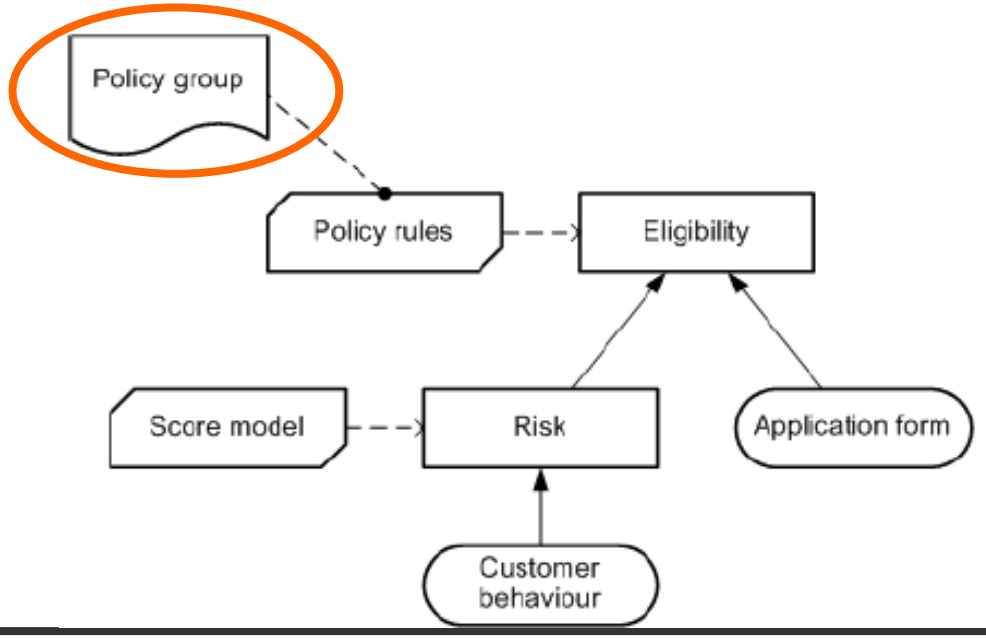
- Decisions require are input data.
- Input data elements typically represent business entities that are being used in the decision making, such as Application Form or Customer Data.





Knowledge Source

- Knowledge sources represent the source of know-how for making a decision. This could be regulations or policies, best practices or expertise on how a decision should be made.
- Knowledge sources are the authorities for a decision and typically refer to some external document or source that contains detailed guidance



DRD Requirements

Shows that Input Data or Decision output is required as an input by another Decision

Shows that a Business Knowledge Model is invoked by a Decision or another Business Knowledge Model

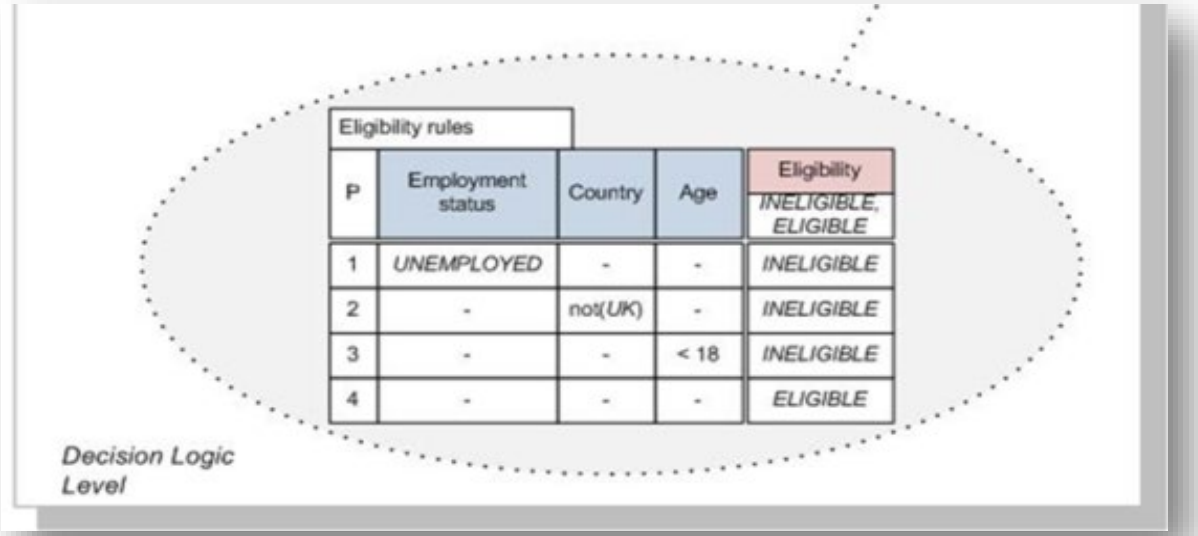
Shows the dependency of a DRD Element on a Knowledge Source

Main concepts – Decision Logic

Detailed criteria for decision making

- Business rules
- Calculations
- Decision Tables
- Scripts

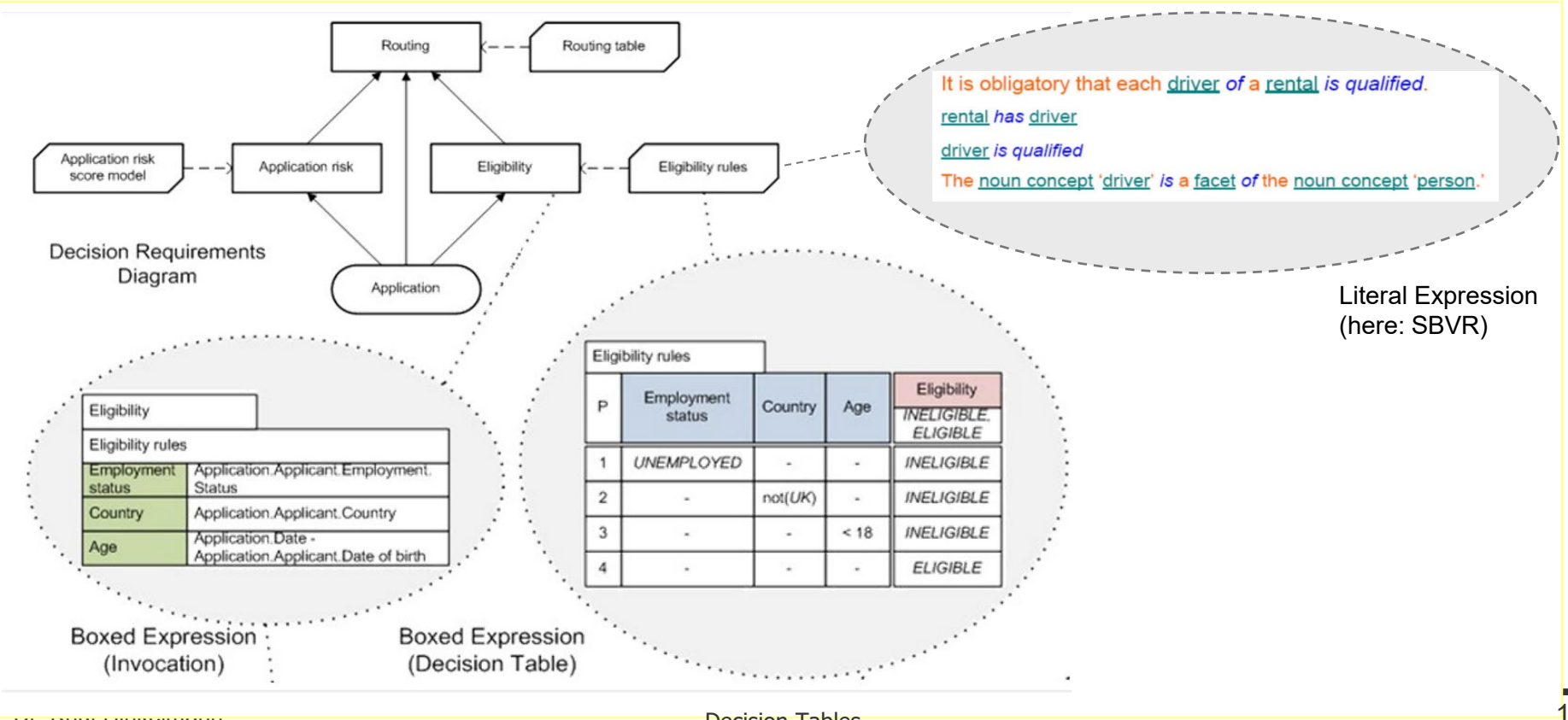
Decision Logic



(Coenen 2013)

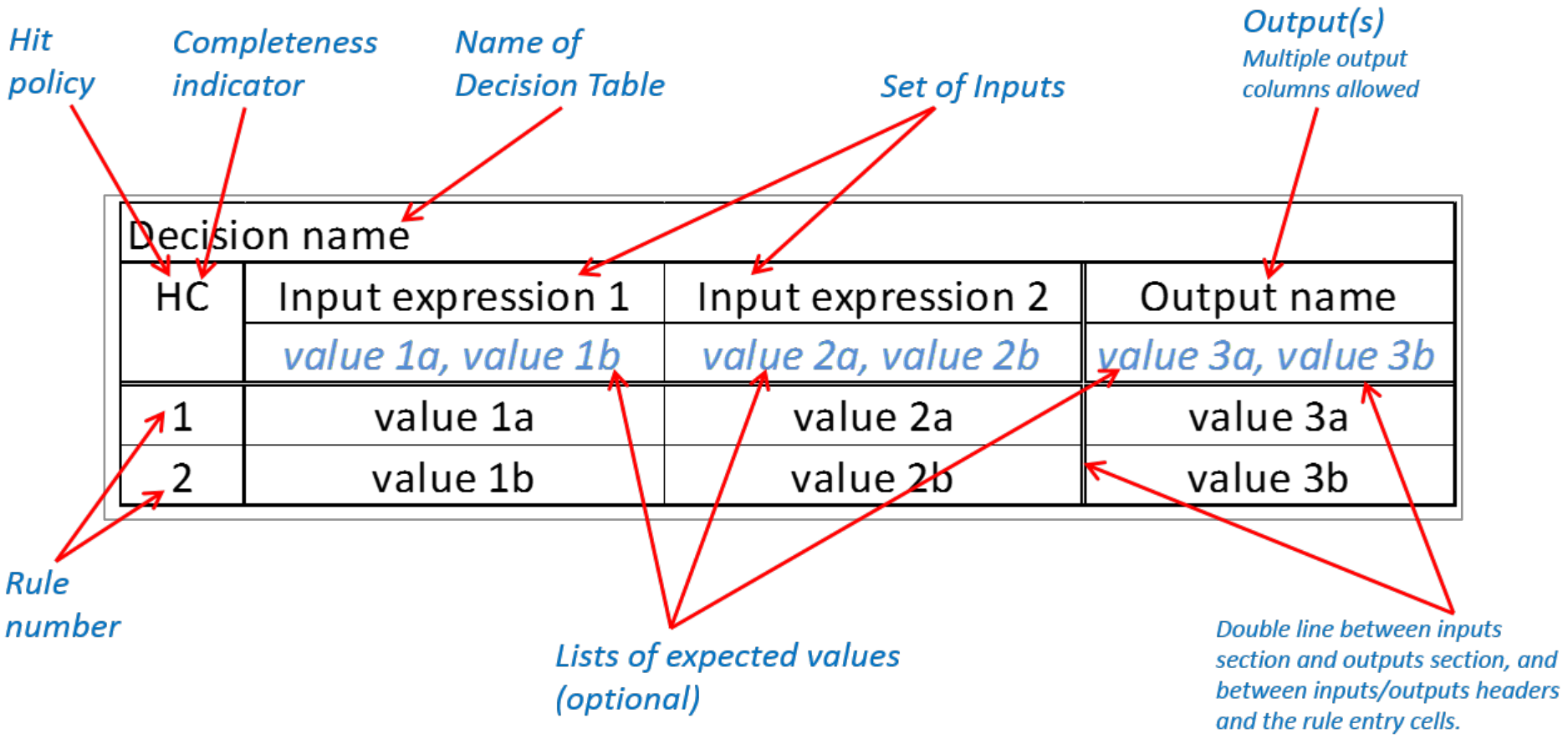
Linking Requirements Diagram with Decision Logic

- The notation for decision logic in DMN is a
  - Decision Table
  - Invocation
  - Literal expression (business rule)
- Decision logic can be assigned to Decision or Business Knowledge elements



"I'm here because my boss said we should use more decisions tables for our project. What types of decision tables do you sell?"

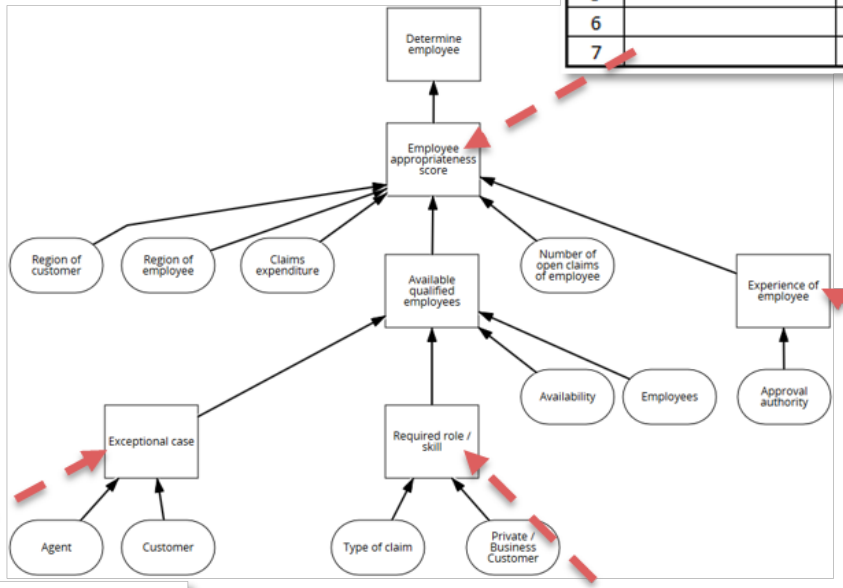
Structure of a Decision Table in DMN



Decision Tables

Employee appropriateness score

C	Region of employee = Region of customer	Claims Expenditure (estimated)	Experience of employee	Number of open claims of employee	Score
	yes/no	Number	low/medium/high	Number	Number
1	yes				100
2		[1000..10000]	low		-100
3		> 10000	low		-1000
4		> 10000	medium		-100
5				[10..20]	-100
6				[20..30]	-500
7				> 30	-1000



Experience of Employee

	Approval Authority	Experience
1	< 1000	low
2	[1000..10000]	medium
3	> 10000	high

Exceptional Case

	Agent Id	Customer Frame Contract Id	Required Role	Special Employee
1	4711		Special Customer Task Force Berlin	
2		0815	Special Customer Task Force Berlin	
3		camunda		Mr. Important
4	...	...	...	...

Required Skill / Role

	Type of Claim	Private/Business Customer?	Required Role	Required Skill
1	Third Party Liability	Private	Service Center	
2	Third Party Liability	Business	Service Center	Business Law Qualification
3	Accident	Private	Service Center	
4	Accident	Business	Business Accident Team	
5	...	...	...	

Decision Tables – Reducing Combinations

- If effects for several combinations are the same, the combinations can be combined, reducing the number of rules
- Example:
  - If Cause 1 is „yes“, the effect does not depend on the value of Cause 2
  - In this case, the value of Cause 2 does not need to be taken into account

effect

	Cause1	Cause 2	Effect
	yes, no	*yes, no*	*E1, E2, E3*
1	yes	yes	E1
2	yes	no	E1
3	no	yes	E2
4	no	no	E3

effect

	Cause1	Cause 2	Effect
	yes, no	*yes, no*	*true, false*
1	yes	-	E1
2	no	yes	E2
3	no	no	E3

Exercise: Reduce decision table

- The following decision table represents rules for reimbursing expenses by health insurance
- Reimbursement depends on three conditions:
  - whether decuctible is already met,
  - whether the patient visited the doctor‘s office (D), a hospital (H) or a lab (L) and
  - whether – in case of a visit at the doctor’s office – the physician is present
- The decision table is complete showing all combinations of decisions. Reduce the table to only the really needed number of rules

Reimbursement				
	Deductable met	Type of visit	Physician present	Reimbursement
	yes, no	*D, H, L*	*yes, no*	*integer*
1	yes	D	yes	90
2	yes	D	no	50
3	yes	H	yes	80
4	yes	H	no	80
5	yes	L	yes	70
6	yes	L	no	70
7	no	D	yes	0
8	no	D	no	0
9	no	H	yes	0
10	no	H	no	0
11	no	L	yes	0
12	no	L	no	0

Reduced Decision Table for Health Insurance

Reimbursement depends on whether decuctible is already met, whether the patient visited the doctor ‘s office (D), a hospital (H) or a lab (L) and whether the Doctor in the doctor ‘s office is a Participating Physician

Reimbursement

	Deductable met	Type of visit	Physician present	Reimbursement
	yes, no	*D, H, L*	*yes, no*	*integer*
1	yes	D	yes	90
2	yes	D	no	50
3	yes	H	-	80
4	yes	L	-	70
5	no	-	-	0

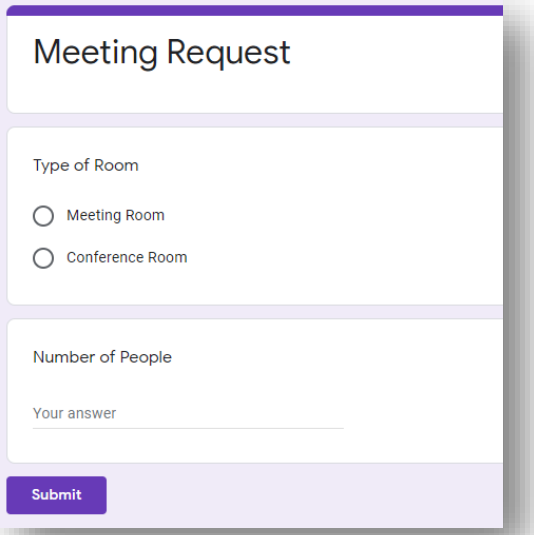
- A Hospital visit and a Lab visit have the same reimbursement, independent of a participating physician.

- If the deductible is not met, no reimbursement is given, independent of the other conditions

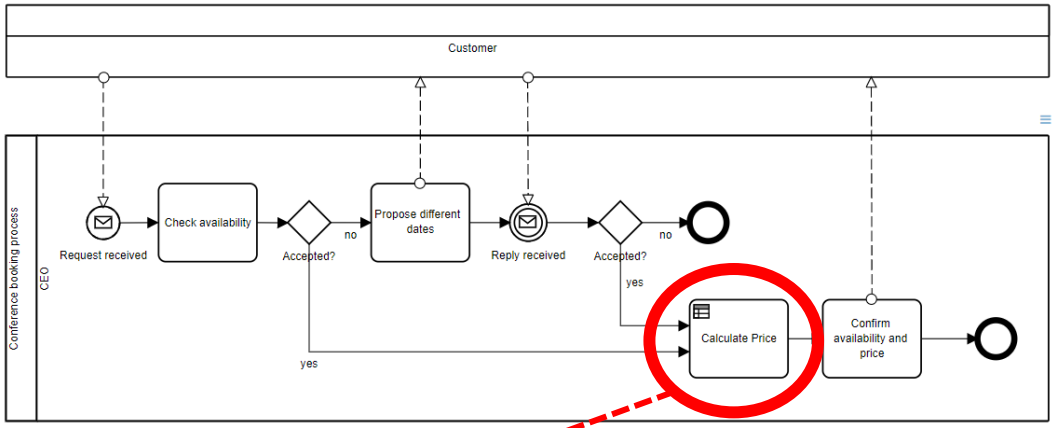
http://web.sxu.edu/rogers/sys/decision_tables.html

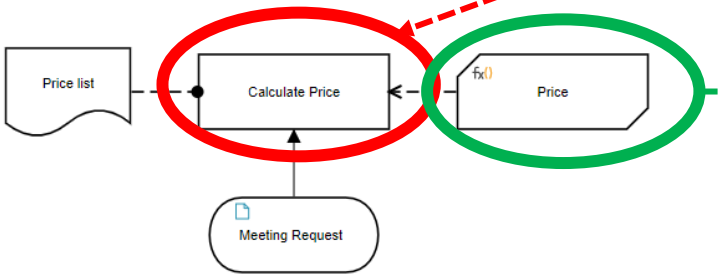
Scenario

- In a conference center one can book different kinds of rooms. The prices for the rooms are shown in the price list. Customers use a form for their enquiry.
- These are the criteria for calculating the price:
  - The rent for a meeting room is € 500.
  - The rent for a conference room depends on the number of people. For more than 30 people it is € 1200, otherwise € 800
- Task:
  - Create a decision requirements diagram
  - Create the decision table for the price calculation



Decision Aware Representation of Booking Process with Price Calculation

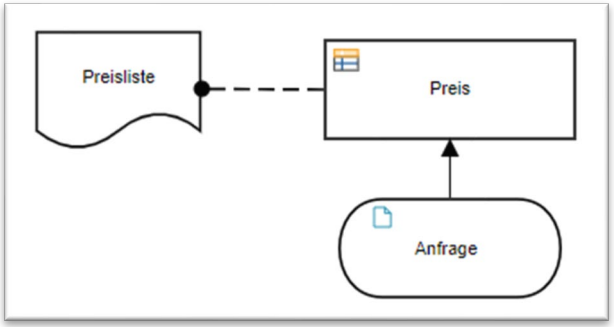


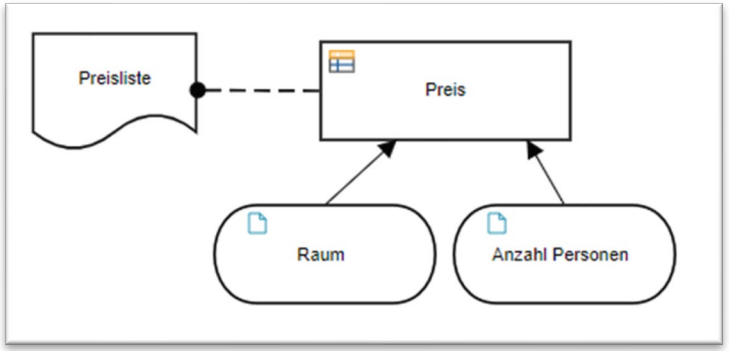


U	Type of Room	Number of People	Price
	Text *"Meeting Room", "Conference Room"*	*Number*	*Number*
1	"Meeting Room"	-	500
2	"Conference Room"	<=30	800
3	"Conference Room"	>30	1200

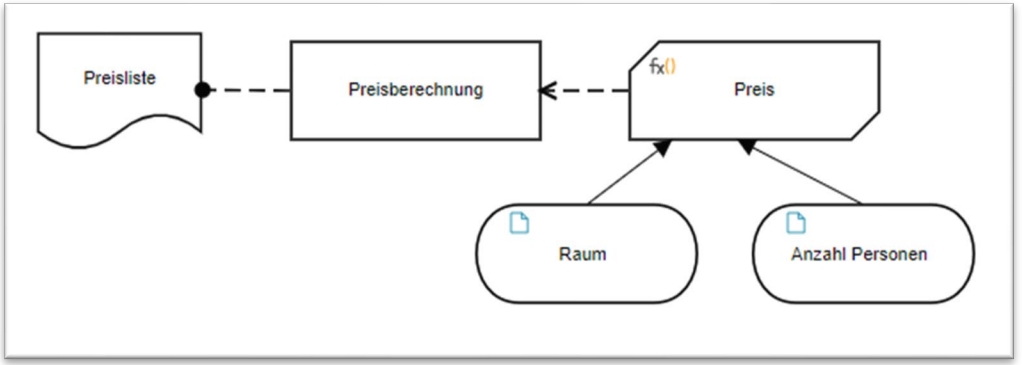
Decision Requirements Diagram - Variants

- Decision Table assigned to Decision Element





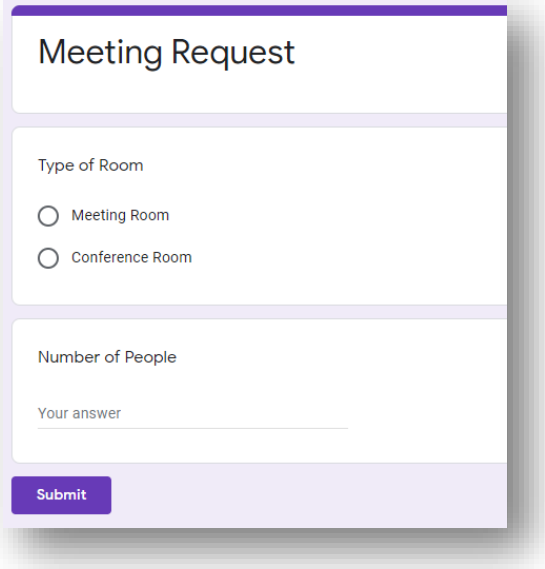
- Decision Tabele assigned to Business Knowledge Element



*) In Trisotech werden bei der Ausführung für jeden Input Data ein Wert abgefragt. Daher ist Variatnte 1 in Tristech nicht ausführbar

Input Data and Decision Table

- The data types of the decision must match the input data
- This decision table fits for the input data: appropriate data types
  - Enumeration
  - Number



U	Type of Room	Number of People	Price
	Text *"Meeting Room", "Conference Room"*	*Number*	*Number*
1	"Meeting Room"	-	500
2	"Conference Room"	<=30	800
3	"Conference Room"	>30	1200

Datentypen in Entscheidungstabellen

Name	Description	Example
Boolean	two possible values true or false.	true false
String	plain text written in "quotes" or italics.	"Trisotech" Trisotech
Number	numerical value.	1000 5.1
Date	YYYY-MM-DD format written in bold italic or as a function parameter string.	2017-11-27
Time	HH:MM:SS format written in bold italic or as a function parameter string.	09:12:00
Date and Time	YYYY-MM-DDTHH:MM:SS format written in bold italic or as a function paramater string .	2017-11-27T09:12:00
Duration	P[n]Y[n]M[n]DT[n]H[n]M[n]S format where [n] is a number written in bold italic or as a function parameter string.	PT25M is 25 minutes duration("PT15M") is 15 minutes
Null	no other valid value.	null
[n1, n2, n3]	a list of values.	[1,3,7,1] is a list of 4 numbers ["Triso", "tech"] is a list of 2 strings

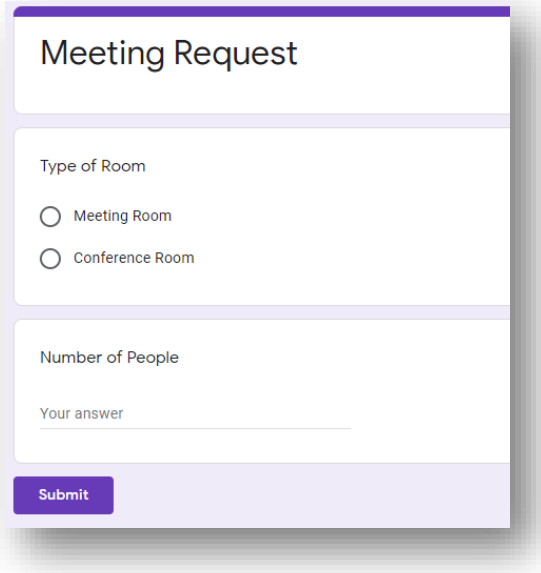
Arithmetische und logische Operatoren

Input Test	Description
val	Equal to val
>val	Greater than val
>=val	Greater or equals to val
<val	Smaller than val
<=val	Smaller or equals to val
[Val1..Val2]	Closed interval, between Val1 and Val2 inclusive
(Val1..Val2)	Open interval, between Val1 and Val2 exclusive.
[Val1..Val2)	Interval, >=Val1 and < Val2
(Val1..Val2]	Interval, >Val1 and <=Val2
not(val)	Is not val
Val1,Val2,Val3	Works as an "or".

Operation	Description
+	Addition
-	Substraction
/	Division
*	Multiplication
**	To the power of

Input Data and Decision Table

- These decision tables do **not** fits for the input data
  - Input for Number of People is a number
  - In decision tables the types for Number of People are different



U	Type of Room	Number of People	Price
	Text *"Meeting Room", "Conference Room"*	*Text* *"<=30", ">30"*	*Number*
1	"Meeting Room"	-	500
2	"Conference Room"	"<=30"	800
3	"Conference Room"	">30"	1200

Enumeration (text)
'<=30' '>30'

U	Type of Room	Number of People	Price
	Text *"Meeting Room", "Conference Room"*	*Boolean* *>30*	*Number*
1	"Meeting Room"	-	500
2	"Conference Room"	true	800
3	"Conference Room"	false	1200

Boolean
But: Who made the check whether the number is >30 or not?

Hit Policies (1)

- The hit policy specifies what the result of the decision table is, if there are multiple matches for a given set of inputs.
- The hit policy indication is mandatory and is summarized using a single character in a particular decision table cell.

Single Hit Policies:

Hit Policy	Description
Unique	This is the default policy. All rules are exclusive and only a single rule is matched.
Any	Multiple matching rules, all matching rules with the same output. Any of these outputs can be used.
Priority	Multiple matching rules with different outputs. Returns the matching rule with the highest output priority which is specified in an ordered list of values, e.g. the list of expected output values.
First	Multiple matching rules with different outputs. First hit by rule order is returned. Once there is a hit, the evaluation stops (and ignore the rest of the rules). The matching has a dependency on the order of the rules. The last rule is often the *catch-remainder* rule. **This type of policy is hard to validate manually and must be used with care.**

Hit Policy Any

- Hit Policy Any is used, for example, to represent a logical AND
  - A certain result is given if all criteria are met
  - As soon as one criterion is not fulfilled, there is another result
- It is irrelevant which criterion is not fulfilled

A	Availability	Capacity	Reservation
	Text *"available", "occupied"*	*Text* *"too small", "fitting"*	*Text* *"yes", "no"*
1	"available"	"fitting"	"yes"
2	-	"too small"	"no"
3	"occupied"	-	"no"

Example: A reservation is made, if a fitting room is available

Hit Policy Any

- For Hit Policy Any the order of rules does not matter

A	Availability	Capacity	Reservation
	Text *"available", "occupied"*	*Text* *"too small", "fitting"*	*Text* *"yes", "no"*
1	"available"	"fitting"	"yes"
2	-	"too small"	"no"
3	"occupied"	-	"no"

A	Availability	Capacity	Reservation
	Text *"available", "occupied"*	*Text* *"too small", "fitting"*	*Text* *"yes", "no"*
1	-	"too small"	"no"
2	"available"	"fitting"	"yes"
3	"occupied"	-	"no"

Hit Policy First

- With Hit Policy First, the rules are tested in the order in which they occur.
- As soon as a rule is applicable, the result is delivered; further rules are ignored.
- The Hit Policy First corresponds to a sequence of IF … THEN … ELSE …
- The last rules is often interpreted as ELSE

F	Availability	Capacity	Reservation
	Text *"available", "occupied"*	*Text* *"too small", "fitting"*	*Text* *"yes", "no"*
1	"available"	"fitting"	"yes"
2	-	-	"no"

Another Example for Hit Policy First

- Hit Policy First can simplify tables

Hit Policy Any

A	Credit risk category	Affordability category	Loan approval
	tCreditRiskCategory "High", "Medium", "Low"	*tAffordabilityCategory "Affordable", "Marginal", "Unaffordable"*	*tLoanApproval "Approved", "Declined"*
1	"High"	-	"Declined"
2	-	"Unaffordable"	"Declined"
3	"Medium", "Low"	"Affordable", "Marginal"	"Approved"

Hit Policy First

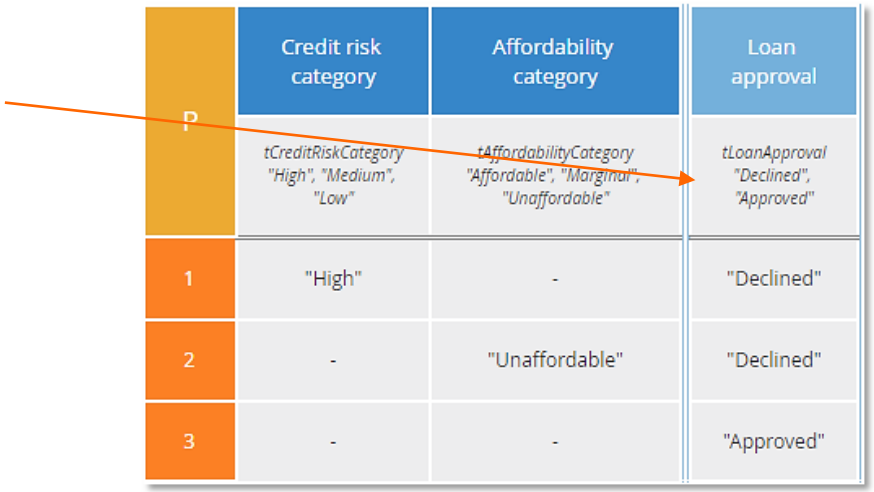
F	Credit risk category	Affordability category	Loan approval
	tCreditRiskCategory "High", "Medium", "Low"	*tAffordabilityCategory "Affordable", "Marginal", "Unaffordable"*	*tLoanApproval "Declined", "Approved"*
1	"High"	-	"Declined"
2	-	"Unaffordable"	"Declined"
3	-	-	"Approved"

As the logic of decision tables should be declarative, the hit poicly F is often dispraised (Silver 2016)

https://www.trisotech.com/dmn-hit-policy-explained/

Hit Policy Priority

- The Hit policy Priority prefers rules, whose result has higher priority
- In enumeration types the order of the values determines the priority



P	Credit risk category	Affordability category	Loan approval
	tCreditRiskCategory "High", "Medium", "Low"	*tAffordabilityCategory "Affordable", "Marginal", "Unaffordable"*	*tLoanApproval "Declined", "Approved"*
1	"High"	-	"Declined"
2	-	"Unaffordable"	"Declined"
3	-	-	"Approved"

https://www.trisotech.com/dmn-hit-policy-explained/

Hit Policies First und Priority

- In this example, Hit Policy First and Hit Policy Priority have the same results because the order of the rules is such that the values with high priority come first.

P	Credit risk category	Affordability category	Loan approval
	tCreditRiskCategory "High", "Medium", "Low"	*tAffordabilityCategory "Affordable", "Marginal", "Unaffordable"*	*tLoanApproval "Declined", "Approved"*
1	"High"	-	"Declined"
2	-	"Unaffordable"	"Declined"
3	-	-	"Approved"

F	Credit risk category	Affordability category	Loan approval
	tCreditRiskCategory "High", "Medium", "Low"	*tAffordabilityCategory "Affordable", "Marginal", "Unaffordable"*	*tLoanApproval "Declined", "Approved"*
1	"High"	-	"Declined"
2	-	"Unaffordable"	"Declined"
3	-	-	"Approved"

https://www.trisotech.com/dmn-hit-policy-explained/

Hit Policy Priority

- Hit Policy Priority can make interpretation of taUntebles difficult

P	isAffordable	RiskCategory	Approval Status
	Boolean	*tRiskCategory "High", "Low", "Medium"*	*tApprovalStatus "Approved", "Declined", "Referred"*
1	true	"Low"	"Approved"
2		"High"	"Declined"
3	-	"Medium"	"Referred"
4	false	-	"Declined"

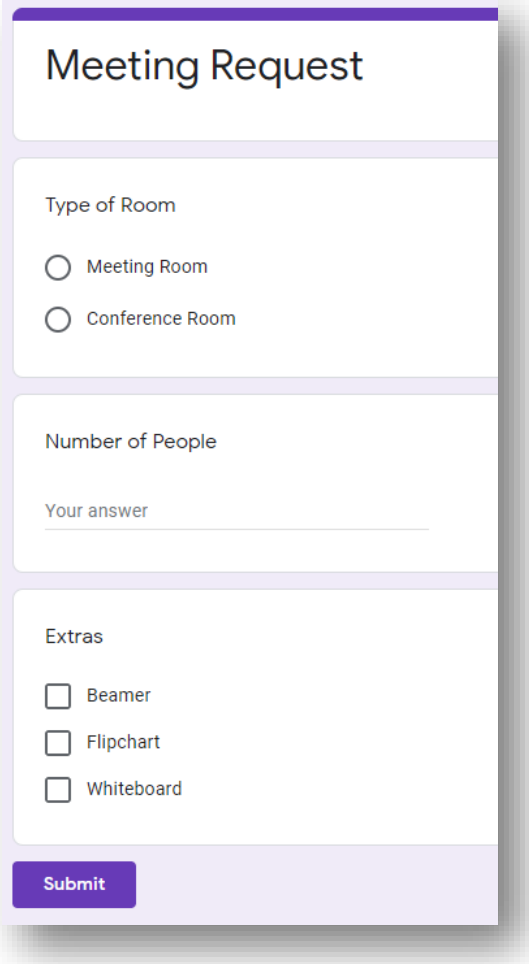
Under which conditions the result "Reffered"?

if RiskCategory is "Medium"

and if IsAffordable not "false"

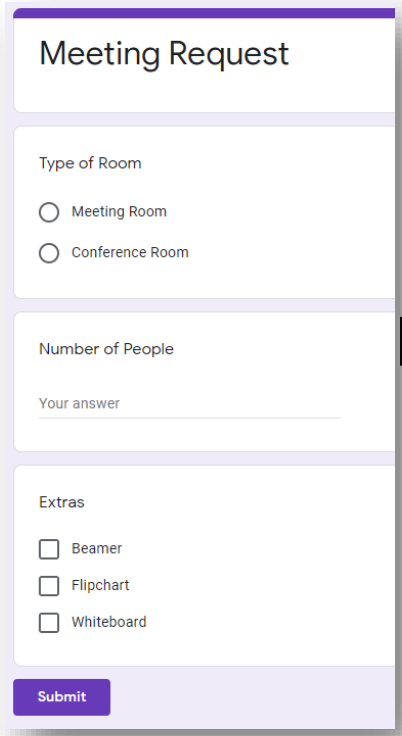
Scenario Extended

- Customers have the option of booking extras in addition to the room.
- The costs are as follows
  - Projector: € 60
  - Flipchart: € 30
  - Whiteboard: € 40
- How can this be presented as a decision table?



Example for Multiple Hit Policy

Collect – Sum
Apply all possible rules and sum up the values. This gives the overall price of room and extras



C+	Type of Room	Number of People	Extras	Price
	Text *"Conference Room", "Meeting Room"*	*Number*	*Text* *"Beamer", "Flipchart", "Whiteboard"*	*Number*
1	"Conference Room"	<=30	-	800
2	"Conference Room"	>30	-	1200
3	"Meeting Room"	-	-	500
4	-	-	"Beamer"	60
5	-	-	"Flipchart"	30
6	-	-	"Whiteboard"	40

Hit Policies (2)

Multiple Hits Policies for Single Output

Hit Policy	Description
No order	Returns all hits in a unique list in arbitrary order.
Output order	Returns all hits in decreasing priority order. Output priorities are specified in an ordered list of values.
Rule order	Returns all hits in rule order, i.e. dependency on the order of the rules.

Aggregation for Multiple Hits Policy

Aggregation	Description
Collect	The result of the decision table is the list of all the outputs, ordered or unordered per the hit policy.
Sum	The result of the decision table is the sum of all the outputs.
Min	The result of the decision table is the smallest value of all the outputs.
Max	The result of the decision table is the largest value of all the outputs.
Count	The result of the decision table is the number of outputs.
Average	The result of the decision table is the average value of all the outputs, defined as the sum divided by the count.

Wrong table

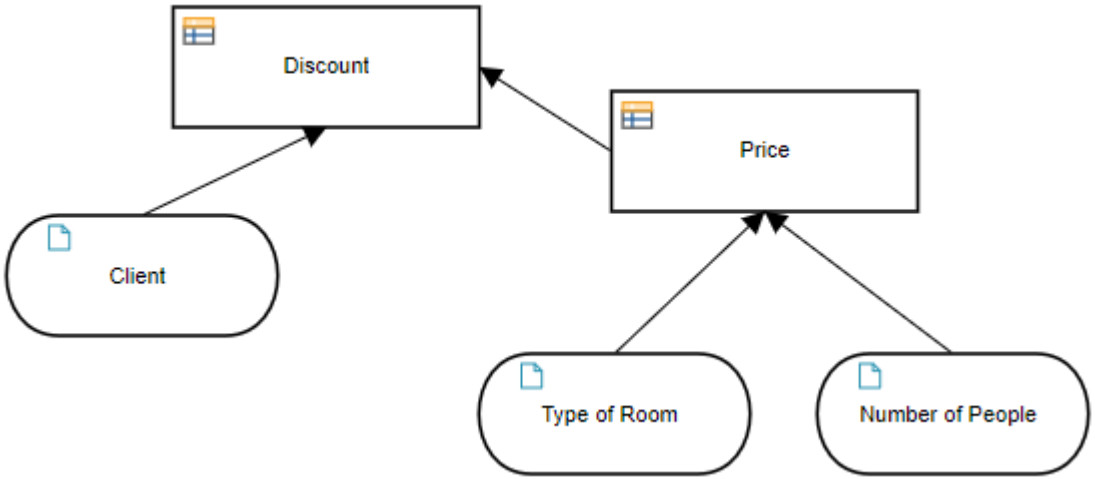
- What is wrong with this table?

U	Credit score	DTI	Loan Approval
	Number	*Number*	*tLoanApproval "Approved", "Declined"*
1	>660	<=0.35	"Approved"
2	>=660	>=0.38	"Declined"
3	[600..660]	<=0.35	"Approved"
4	[600..660]	>0.35	"Declined"
5	<600	-	"Declined"

Severity	Message	Element
⚠	Gap detected: [>660, (0.35 .. 0.38)]	Loan Approval
⊠	Overlap detected: Overlap values: [660, >=0.38] for rules: [4, 2]. UNIQUE hit policy decision tables can only have one matching rule.	Loan Approval
⚠	Table is not fully contracted. Combine rules [1, 3] by joining input 1.	Loan Approval

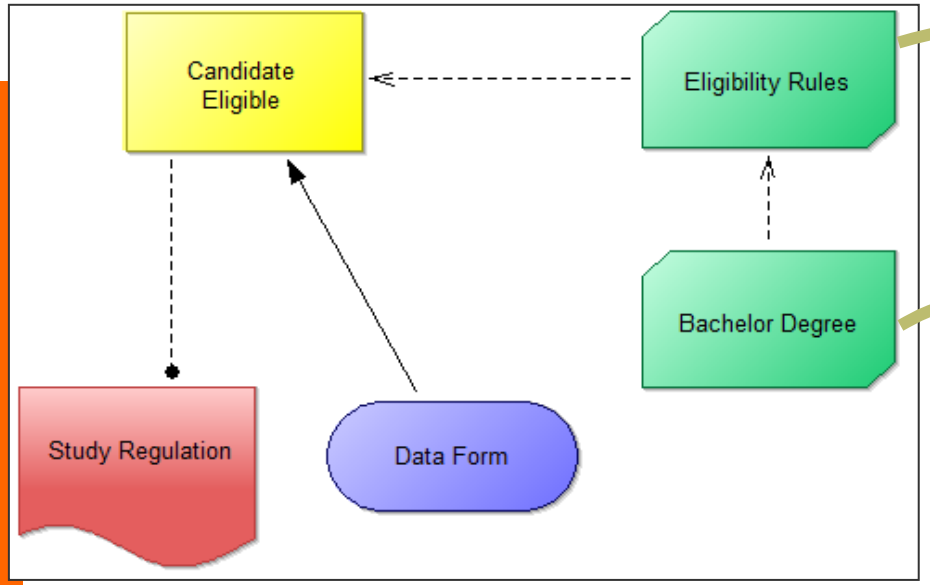
Subdecisions:
Result of one decision is input to another decision

- Schools and sports clubs receive a 10% discount if the costs are higher than € 1000
- Companies and private individuals do not receive a discount



Subdecisions:
Result of one decision is input to another decision

Decision Requirements Diagram



Decision Tables

Eligibility

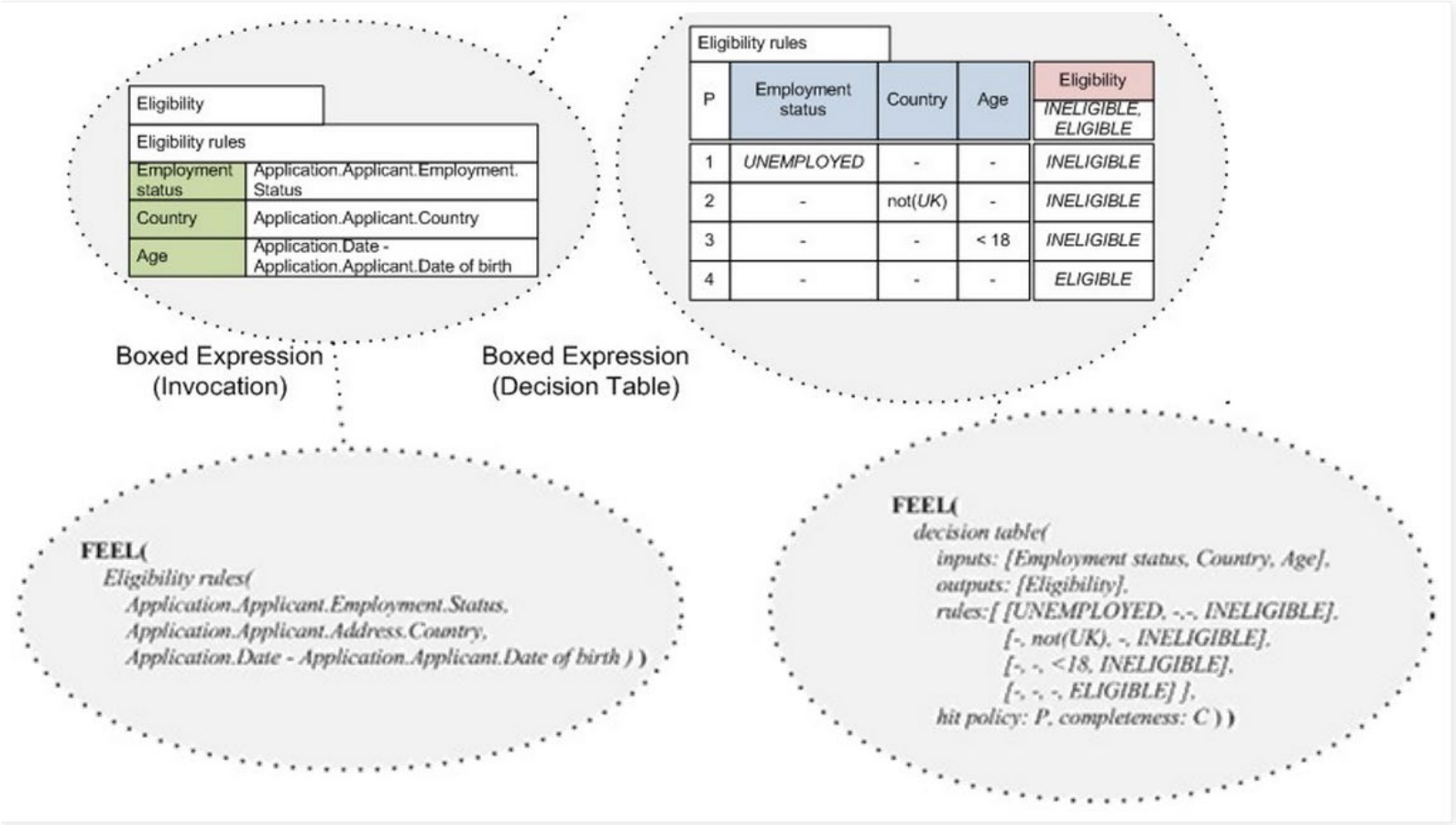
A	Degree valid	University Registered	eligible
	yes,no	*yes, no, unclear*	*yes,no*
1	yes	yes	yes
2	no	-	no
3	-	no	no
4	-	unclear	no

Degree valid

A	Bachelor Degree	Degree valid
	IS, BA, IT, other	*yes,no*
1	IS	yes
2	BA	yes
3	IT	yes
4	other	no

FEEL = Friendly Enough Expression Language

FEEL is a script language for decision tables



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