02291 System Integration

Introduction to DMN

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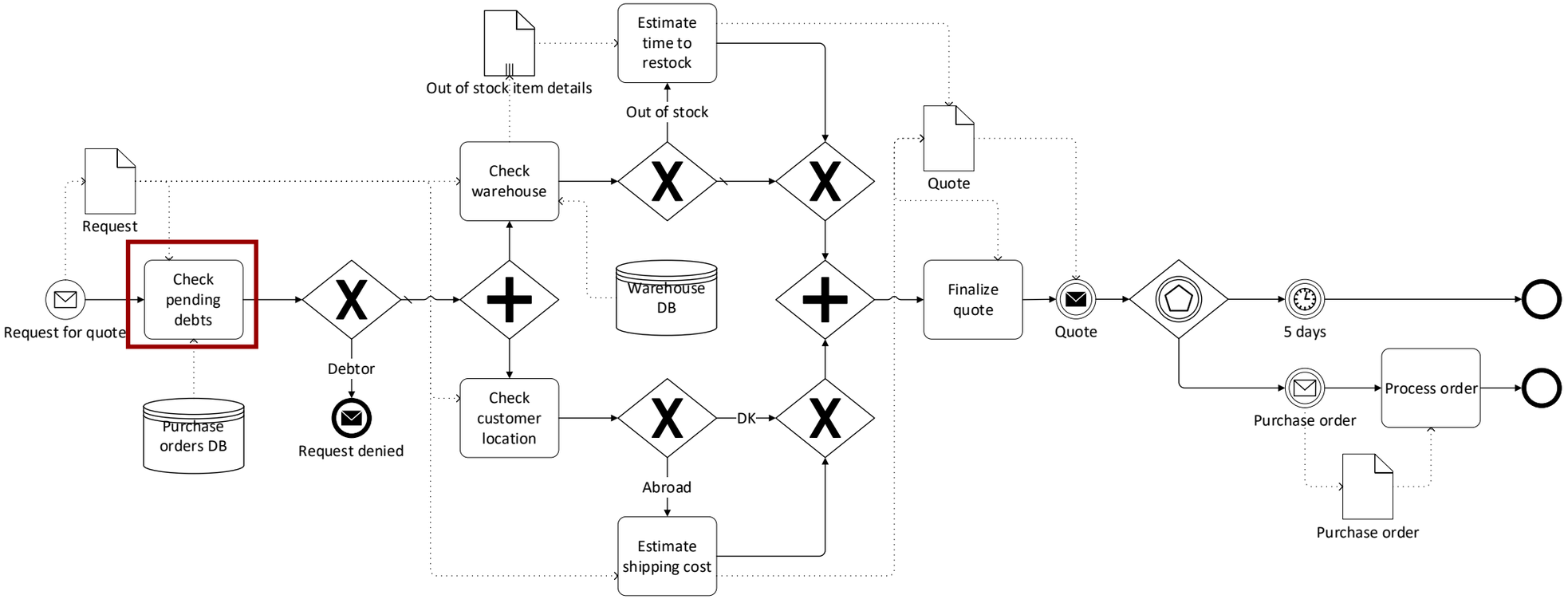
Decisions in BPMN

- In BPMN, decisions are modelled as tasks followed by gateways
- However, it is not explicitly shown:
  - What policies are used to make a decision
  - Which information is used to make a decision
  - Who is responsible for making a decision

Example 3 (from lecture 11)

A supplier of electronic equipment receives a request for a quote from a customer. First, it **checks if the customer has no pending debts**. If this is the case, the request is rejected, and the customer is notified. Otherwise, the supplier checks the availability of the equipment being requested. If it is not in stock, it estimates the time to restock it. In the meantime, if the customer is located outside Denmark, the supplier also estimates the cost to ship the order. When all these steps are completed, the supplier sends the proposal to the customer and waits for a purchase order. When the order arrives, the supplier processes the order, and the process ends. If no response is received within 5 days since the quote was sent, the process ends.

Example 3 (from lecture 11)



Example 3 (extended)

A customer is considered as a debtor based on its fidelity level (gold, silver, bronze), on the payments due, and on the number of unpaid invoices:

- Gold customers are debtors if the total payments due exceed 100000 DKK, regardless of the number of unpaid invoices.
- Silver customers are debtors if the total payments due exceed 10000 DKK or they have more than 5 unpaid invoices.
- Bronze customers are debtors if the total payments due exceed 5000 DKK or they have more than 2 unpaid invoices.

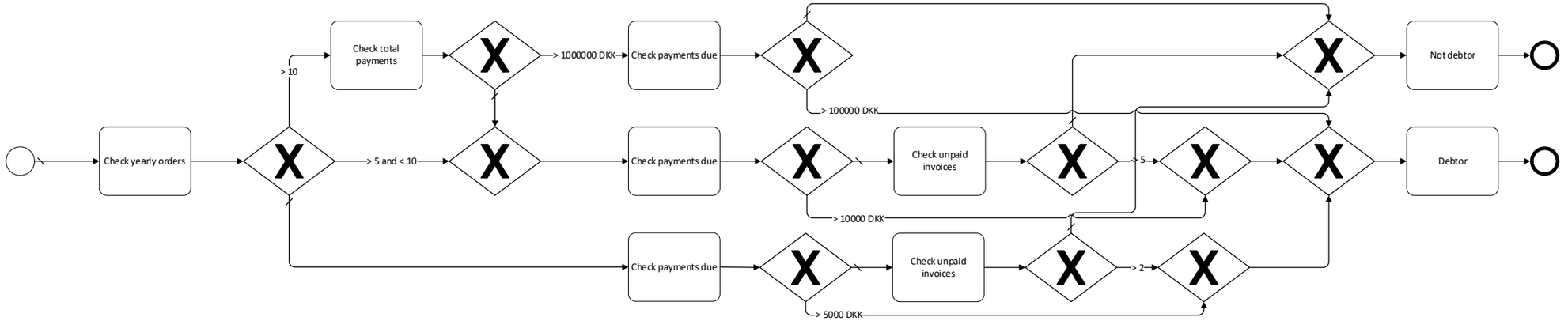
A customer earns gold fidelity level if (s)he places at least 10 orders per year amounting to 1000000 DKK or more in total.

(S)he earns silver fidelity level if (s)he places at least 5 orders per year, independently of the amount.

Otherwise, (s)he earns bronze fidelity level.

Example 3 (extended)

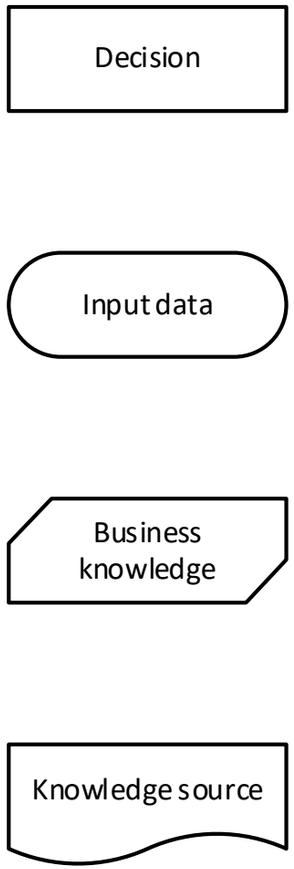
- Difficult to understand
- Has repeated and improper activities
- Embeds the decision logic into the process logic



Introducing DMN

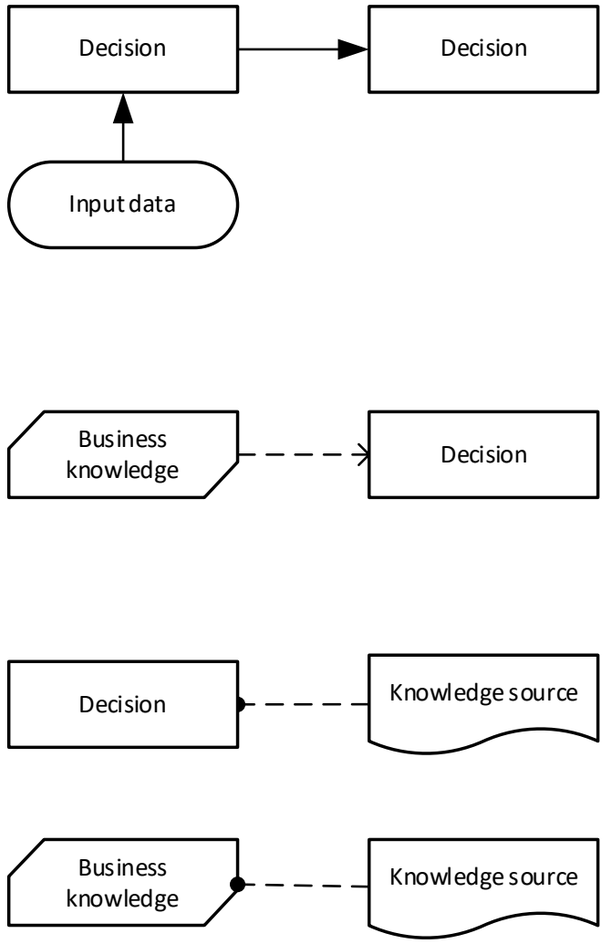
- Decision Model and Notation
- A language to model operational decisions
- Can be understood by both computer scientists and non-computer scientists (Business Analyst, Process Designer, ...)
- Complementary to BPMN

Elements in DMN



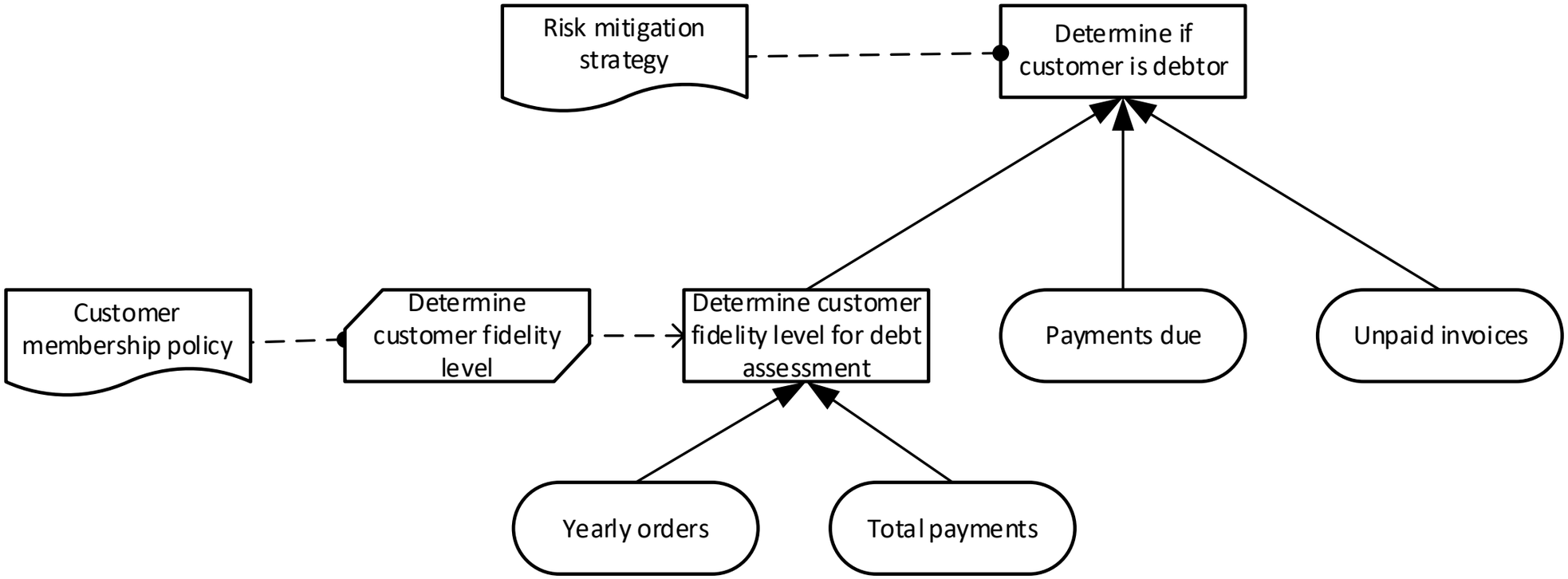
- Decision
  - Logic to make a decision
- Input data
  - Information needed to make a decision
- Business knowledge
  - Logic that can be reused in multiple decisions
- Knowledge source
  - Motivation for a specific decision logic

Elements in DMN



- Information requirements
  - Specify which input data is used for a decision
  - Specify which decision is used in another decision
- Knowledge requirements
  - Specify which business knowledge is used for a decision
- Authority requirements
  - Specify which knowledge source is used for a decision

Example 3 (DMN)



Decisions

- Decisions can be determined by:
  - Expressions: informal (natural language), or executable (FEEL language)
  - Invocations: external software components
  - **Decision tables**: a tabular representation of the decision rules

Decision tables in DMN

Determine if customer is debtor	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	<= 5000	<= 2	**No**
2	Gold	<= 100000	-	**No**
3	Silver	<= 10000	<= 5	**No**
4	-	-	-	**Yes**

Decision tables in DMN

Determine if customer is debtor	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	<= 5000	<= 2	**No**
2	Gold	<= 100000	-	**No**
3	Silver	<= 10000	<= 5	**No**
4	-	-	-	**Yes**

The current table is ambiguous!

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 1, 3 and 4
- We need a mechanism to disambiguate such cases

Hit policies

- Determine which and how many rules are selected:
  - Single hit policies: only one rule can be selected:
  - Multi-hit policies: more than one rule can be selected, and the outcome depends on the output values of the selected rules.

Single hit policies

- Unique (U): only one rule can match each possible input combination
- Any (A): multiple rules can match an input combination, but the outcome must be the same
- Priority (P): multiple rules can match an input combination, and the outcome is determined by the ordering of output values in the output domain
- First (F): multiple rules can match an input combination, and the outcome is determined by the rule that appears first in the table

Decision tables in DMN: First hit policy

Determine if customer is debtor (F)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	<= 5000	<= 2	**No**
2	Gold	<= 100000	-	**No**
3	Silver	<= 10000	<= 5	**No**
4	-	-	-	**Yes**

Ambiguities are resolved

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 1 before 3 and 4
  - “No” is selected

Decision tables in DMN: Priority hit policy

Determine if customer is debtor (P)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	<= 5000	<= 2	**No**
2	Gold	<= 100000	-	**No**
3	Silver	<= 10000	<= 5	**No**
4	-	-	-	**Yes**

Ambiguities are resolved

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 1, 3 and 4
- “No” has higher priority than “Yes”
  - “No” is selected

Decision tables in DMN: Any hit policy

Determine if customer is debtor (A)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	<= 5000	<= 2	**No**
2	Gold	<= 100000	-	**No**
3	Silver	<= 10000	<= 5	**No**
4	-	-	-	**Yes**

The table violates the hit policy!

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 1, 3 and 4
- “Yes” and “No” are different output values
  - We either have to change hit policy, or “fix” the table

Decision tables in DMN: Any hit policy (fixed)

Determine if customer is debtor (A)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	> 100000	-	**Yes**
2	Silver	> 10000	-	**Yes**
3	Silver	-	> 5	**Yes**
4	Bronze	> 5000	-	**Yes**
5	Bronze	-	> 2	**Yes**
6	-	<= 5000	<= 2	**No**
7	Gold	<= 100000	-	**No**
8	Silver	<= 10000	<= 5	**No**

Violations are resolved

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 6 and 8, but both of them give “No” as output

Decision tables in DMN: Unique hit policy

Determine if customer is debtor (U)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	-	> 100000	-	**Yes**
2	Silver	> 10000	-	**Yes**
3	Silver	-	> 5	**Yes**
4	Bronze	> 5000	-	**Yes**
5	Bronze	-	> 2	**Yes**
6	-	<= 5000	<= 2	**No**
7	Gold	<= 100000	-	**No**
8	Silver	<= 10000	<= 5	**No**

The table violates the hit policy!

- A silver customer with 4000 DKK due and 2 unpaid invoices would match entry 6 and 8

Decision tables in DMN: Unique hit policy (fixed)

Determine if customer is debtor (U)	Fidelity level {Gold, Silver, Bronze}	Payments due [0, 10000000]	Unpaid invoices [0,10]	Debtor {Yes, No} No > Yes
1	Gold	> 100000	-	**Yes**
2	Silver	> 10000	> 5	**Yes**
3	Silver	<= 10000	> 5	**Yes**
4	Silver	> 10000	<= 5	**Yes**
5	Bronze	> 5000	> 2	**Yes**
6	Bronze	<= 5000	> 2	**Yes**
7	Bronze	> 5000	<= 2	**Yes**
8	Gold	<= 100000	-	**No**
9	Silver	<= 10000	<= 5	**No**
10	Bronze	<= 5000	<= 2	**No**

Multi-hit policies

- Output order (O): the outcome is a list ordered by the output value
- Rule order (R): the outcome is a list ordered by the rule number
- Collect (C): the outcome is an unordered set
  - (C+) sums the values
  - (C#) counts the values
  - (C<) retrieves the minimum value
  - (C>) retrieves the maximum value

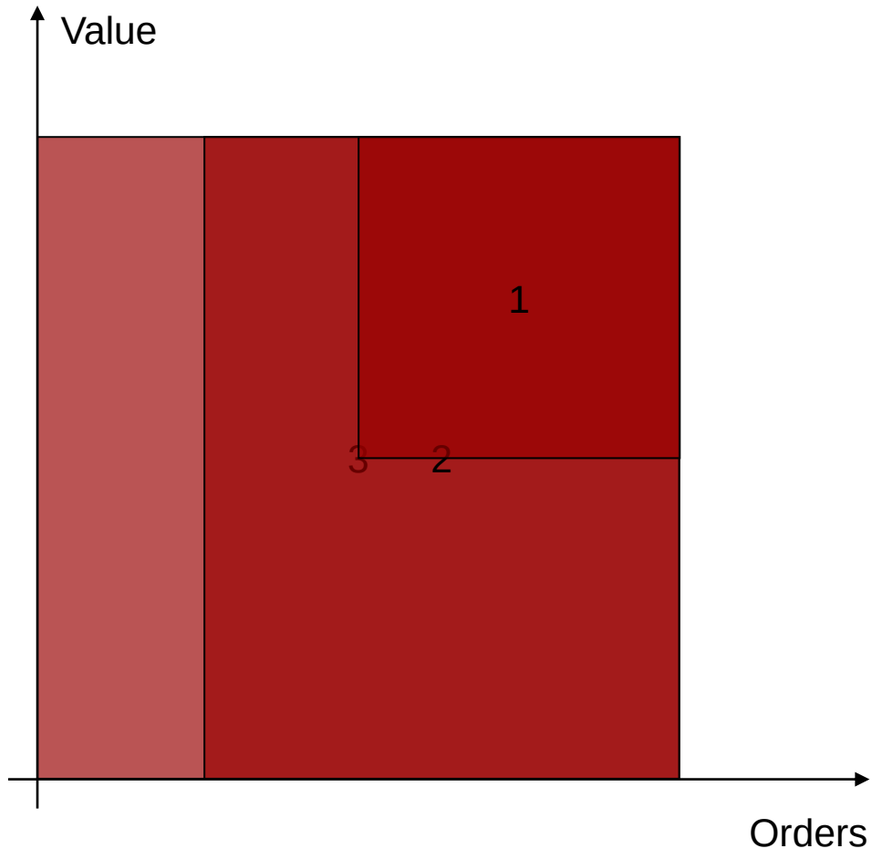
Verification in DMN

- We can see every rule as an iso-oriented hyper-rectangle in an N-dimensional space
  - N is the number of columns
- We can then look for overlapping uncovered areas
  - Overlapping areas indicate potentially conflicting rules
    - Whether a conflict occurs depends on the output value and hit policy
  - Uncovered areas indicate undefined behaviours

Calvanese, Diego, et al. "Semantics and analysis of DMN decision tables." *Business Process Management: 14th International Conference, BPM 2016, Rio de Janeiro, Brazil, September 18-22, 2016. Proceedings 14*. Springer International Publishing, 2016.

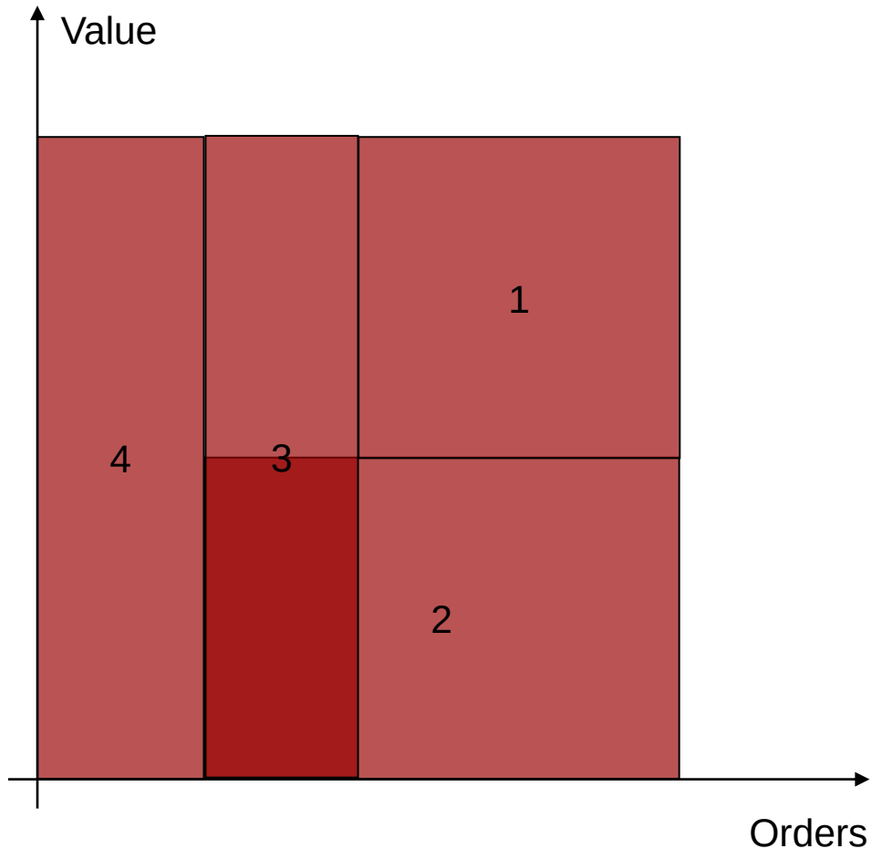
Verification in DMN

Determine customer fidelity (U)	Total orders [0,20]	Total orders value [1,2000000]	Fidelity Level {gold, silver, bronze} Gold>Silver> Bronze
1	>= 10	>= 1000000	**Gold**
2	>= 5	-	**Silver**
3	-	-	**Bronze**



Verification in DMN

Determine customer fidelity (A)	Total orders [0,20]	Total orders value [1,2000000]	Fidelity Level {gold, silver, bronze} Gold>Silver> Bronze
1	>= 10	>= 1000000	**Gold**
2	>= 5	< 1000000	**Silver**
3	[5,9]	-	**Silver**
4	< 5	-	**Bronze**



Verification in DMN

Determine customer fidelity (U)	Total orders [0,20]	Total orders value [1,2000000]	Fidelity Level {gold, silver, bronze} Gold>Silver> Bronze
1	>= 10	>= 1000000	**Gold**
2	>= 5	< 1000000	**Silver**
3	[5,9]	> 1000000	**Silver**
4	< 5	-	**Bronze**

Study material

- Books and articles:
  - Weske - Business Process Management
    - Available at: https://link.springer.com/book/10.1007/978-3-662-59432-2
    - Chapter 5
  - Calvanese et al.: Semantics and Analysis of DMN Decision Tables, BPM 2016 Conference Proceedings, 217-233 (2016)
    - Available at: https://doi.org/10.1007/978-3-319-45348-4_13
- Modeling tools:
  - Camunda DMN-Simulator: https://consulting.camunda.com/dmn-simulator/
  - bpmn.io: https://demo.bpmn.io/
  - (alternatively) SAP Signavio: https://academic.signavio.com/p/login

Exercises

Please answer all exercises to demonstrate your skills.

Solutions will be available at 11:45

Exercise 1

The decision task “Estimate shipping cost” of Example 3 is organized as it follows:

- If the customer is in EMEA, the weight of the package is lower than 10 Kg, and the volume of the package is smaller than 10 cm3, then the cost amounts to 100 DKK. Otherwise, the cost is 300 DKK.
- If the customer is in America or APAC, the weight of the package is lower than 5 Kg, and the volume of the package is smaller than 7 cm3, then the cost amounts to 200 DKK. If the weight of the package is greater than 20 Kg, and the volume of the package is bigger than 30 cm3, then the cost amounts to 2000 DKK. Otherwise, the cost amounts to 1000 DKK.

Implement this task with DMN:

- Draw the DMN diagram of this task
- Implement the decision with a decision table that uses the First (F) hit policy.
- Modify that decision table to use the Any (A) hit policy instead.
- Modify that decision table to use the Unique (U) hit policy instead.

Exercise 2

- Given the following decision table:

Determine discount (?)	Fidelity level {gold, silver, bronze}	Items bought [0,100]	Total value [0,100000]	Discount [0,30] 30>0
1	Gold	> 2	-	**30**
2	Gold	-	-	**10**
3	Silver	-	> 10000	**20**
4	Silver	> 2	-	**10**
5	Bronze	> 2	> 1000	**10**

- Which single hit policies would not cause any violation?
- Would all the previously identified hit policies lead to the same outcome?
- Is the table complete?