

Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules

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13th Americas Conference on Information Systems (AMCIS 2007),
Keystone, Colorado, USA August 9–12 2007

Mini-Track: EBiz & Services: Business Process Automation
and Management

- /// Identification of the Application Domain
“Vagueness in Business Process Management”

- /// Fuzzy Set Theory
 - From Crisp to Fuzzy Sets
 - Linguistic Variables
 - Fuzzy Systems

- /// Fuzzy Enterprise Modelling
 - Existing Approaches and Related Work
 - Intermediate Result

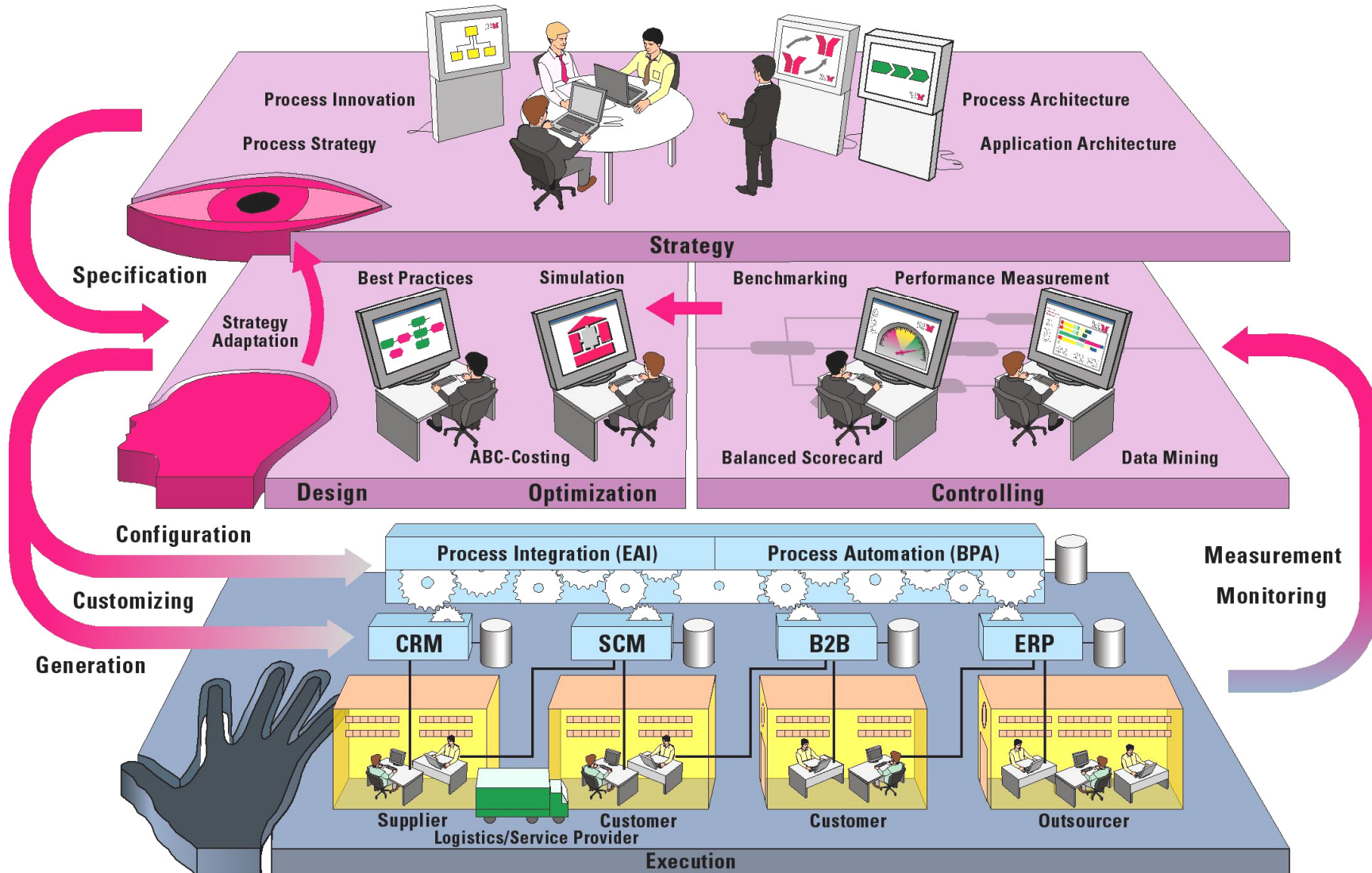
- /// Fuzzy Event-driven Process Chain
 - Reference Process Example and “Fuzzification”
 - Simplified Rule System
 - Fuzzy Modelling Tool

- /// Summary and Outlook

Identification of the Application Domain



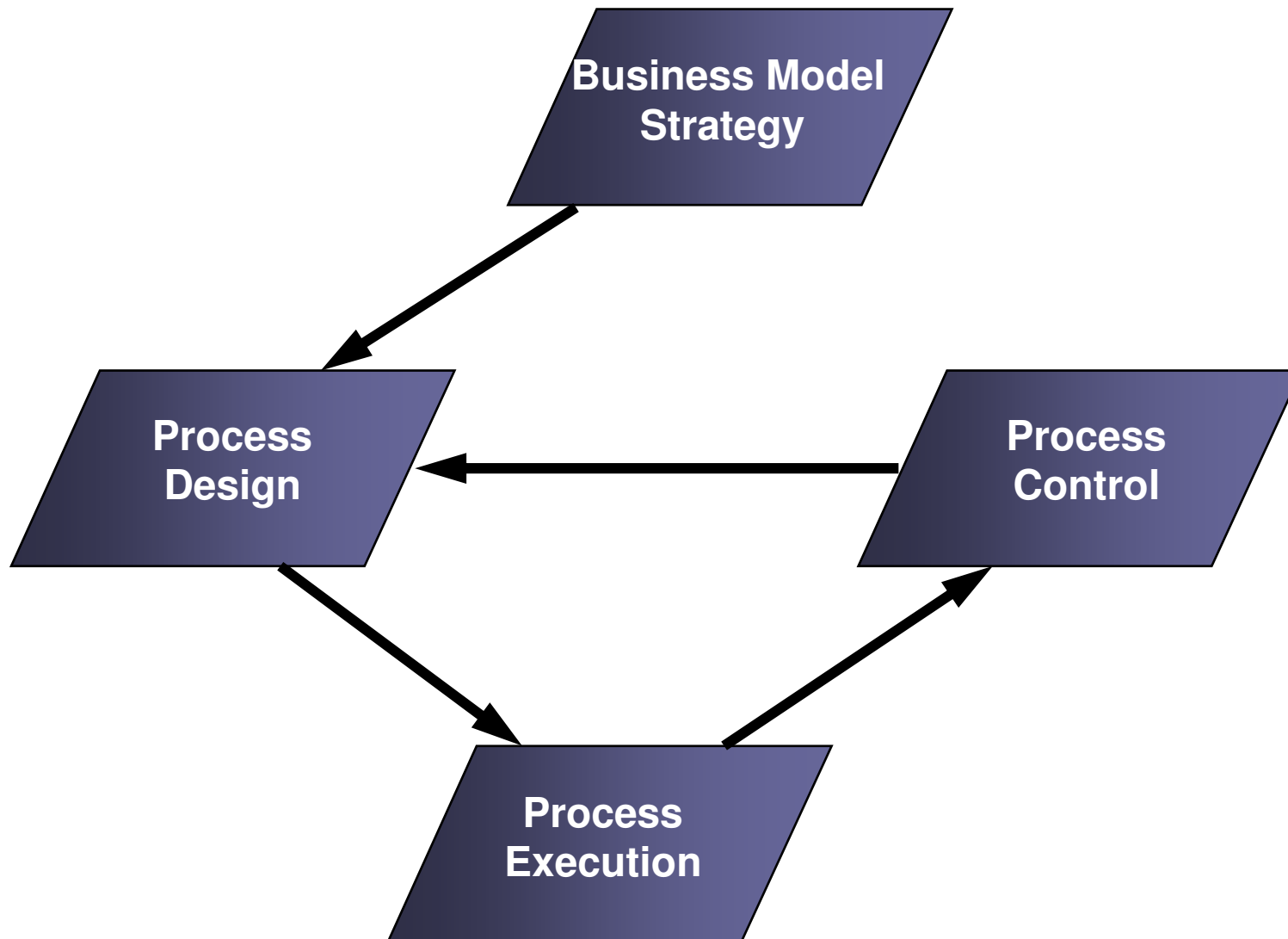
Business Process Management - ARIS-House of Business Engineering (HOBE)



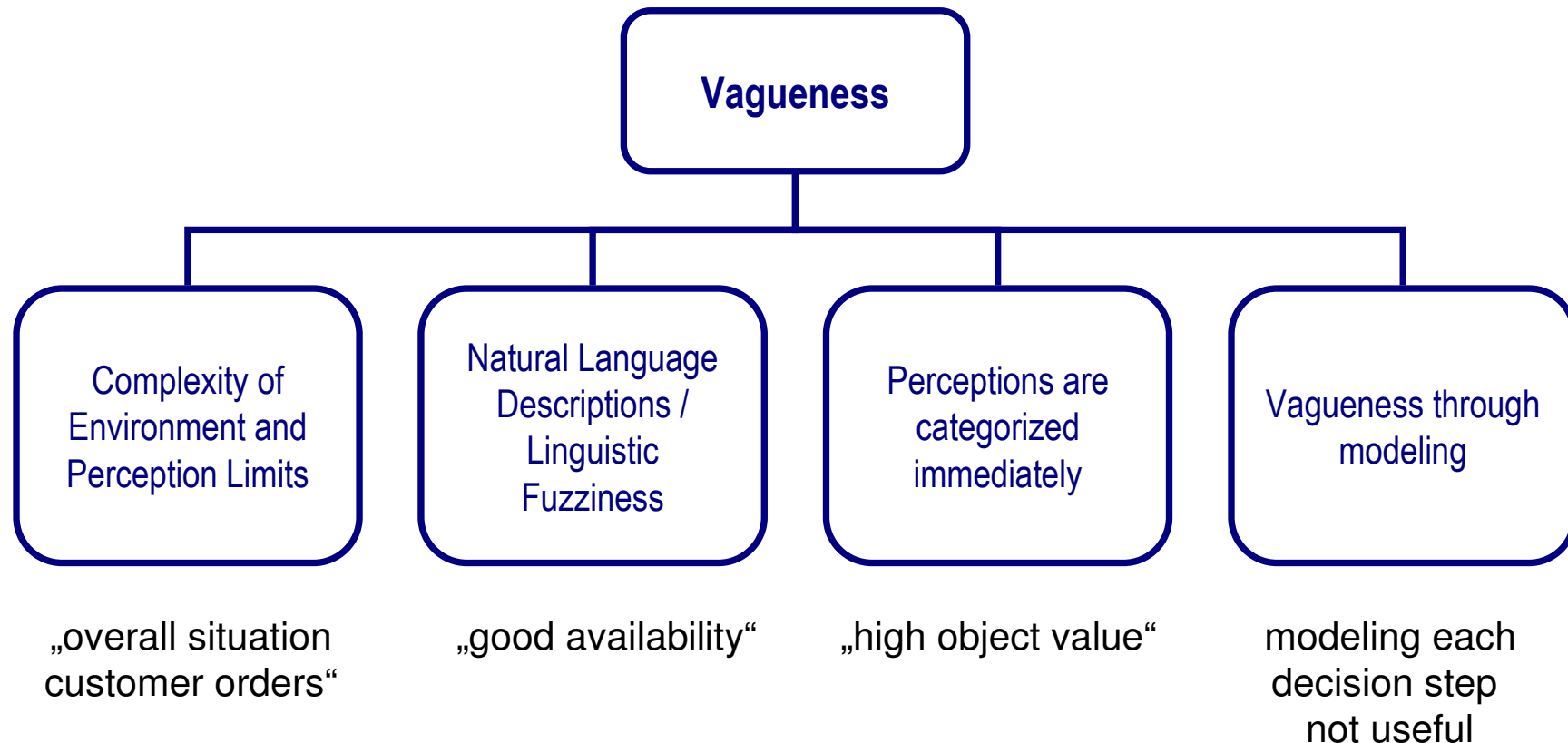
Source: Scheer, A.-W.: ARIS-House of Business Engineering. In: Scheer, August-Wilhelm (ed.): Veröffentlichungen des Instituts für Wirtschaftsinformatik, Nr. 133, Saarbrücken : Universität des Saarlandes, 1996



Life Cycle of Business Processes



Vagueness in Business Process Management



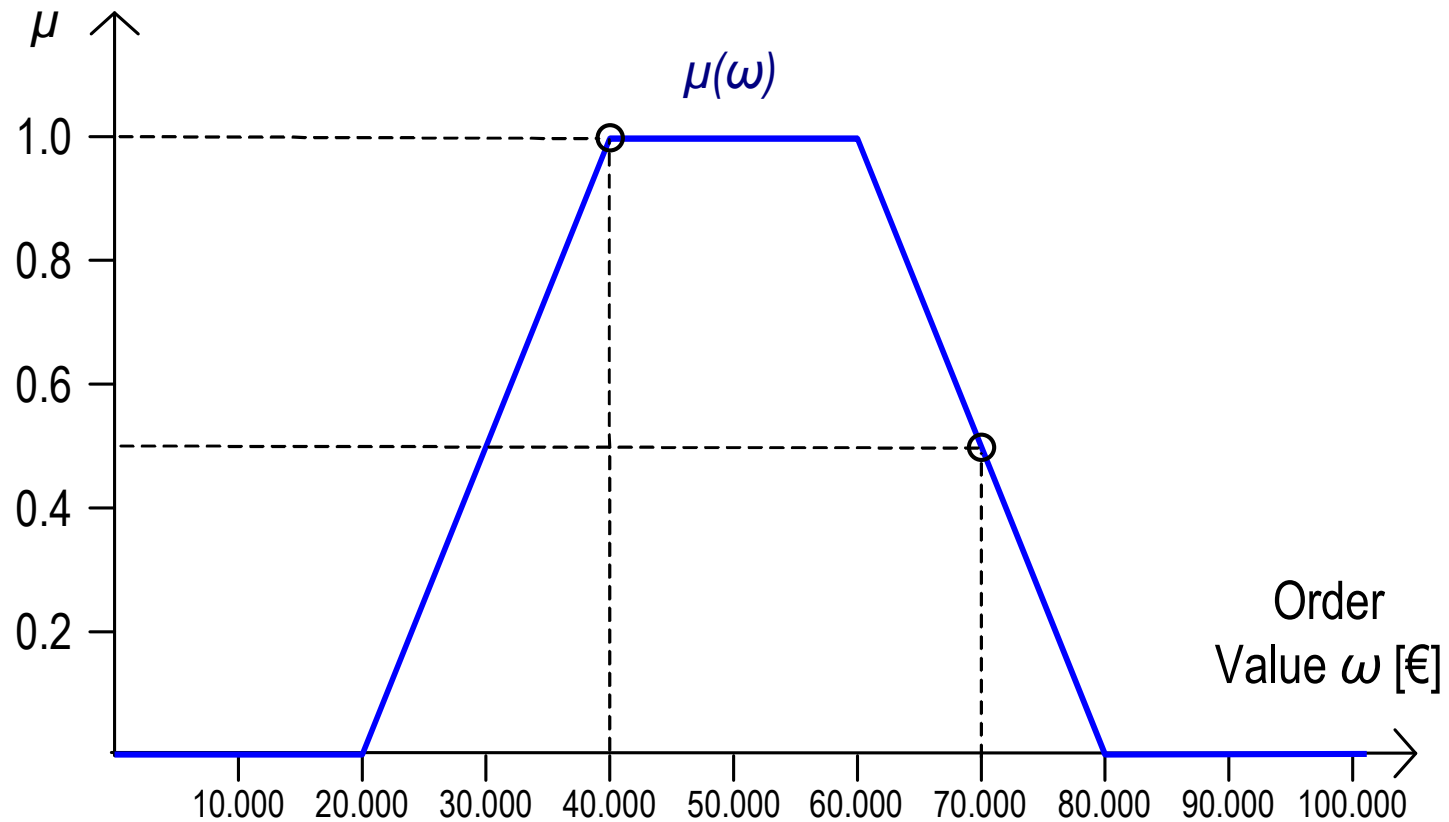
From Crisp to Fuzzy Sets

- /// Sub domain of Soft Computing = Fuzzy Logic + Neural Networks + Evolutionary Computing + Probabilistic Reasoning
- /// Zadeh, Lotfi A.: Fuzzy Sets. In: *Information and Control* 8 (1965), Nr. 3, S. 338-353
- /// *Crucial point in the fuzzy theory*: Not only to evaluate conditions (of objects) with “true” or “false”, but also rather to allow “intermediate stages”.
- /// Subsequent to Zadeh’s original idea, the classic set theory, i. e. the theory of crisp sets, is extended by the description and combination of fuzzy sets.
- /// The grade of membership for each element ω of a predetermined (crisp) basic set Ω to a subset $A \subseteq \Omega$ is expressed by a value $\mu_A(\omega)$ of a mapping $\mu_A : \Omega \rightarrow [0;1]$.
 μ_A is called the membership function of the fuzzy set $\{(\omega; \mu_A(\omega)) \mid \omega \in \Omega\}$.

Fuzzy Set Theory



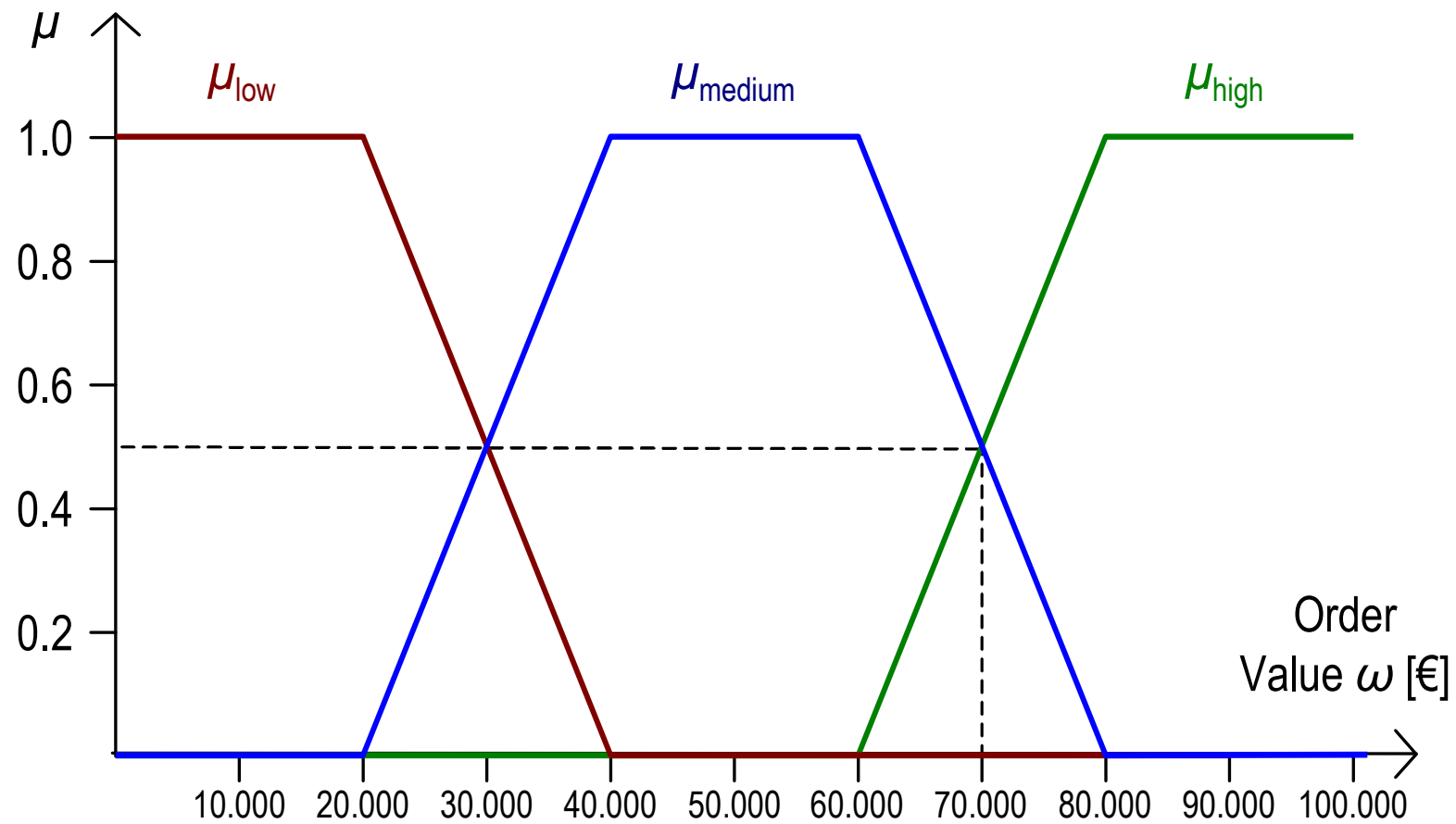
Fuzzy Set "Approximately 50.000 €"



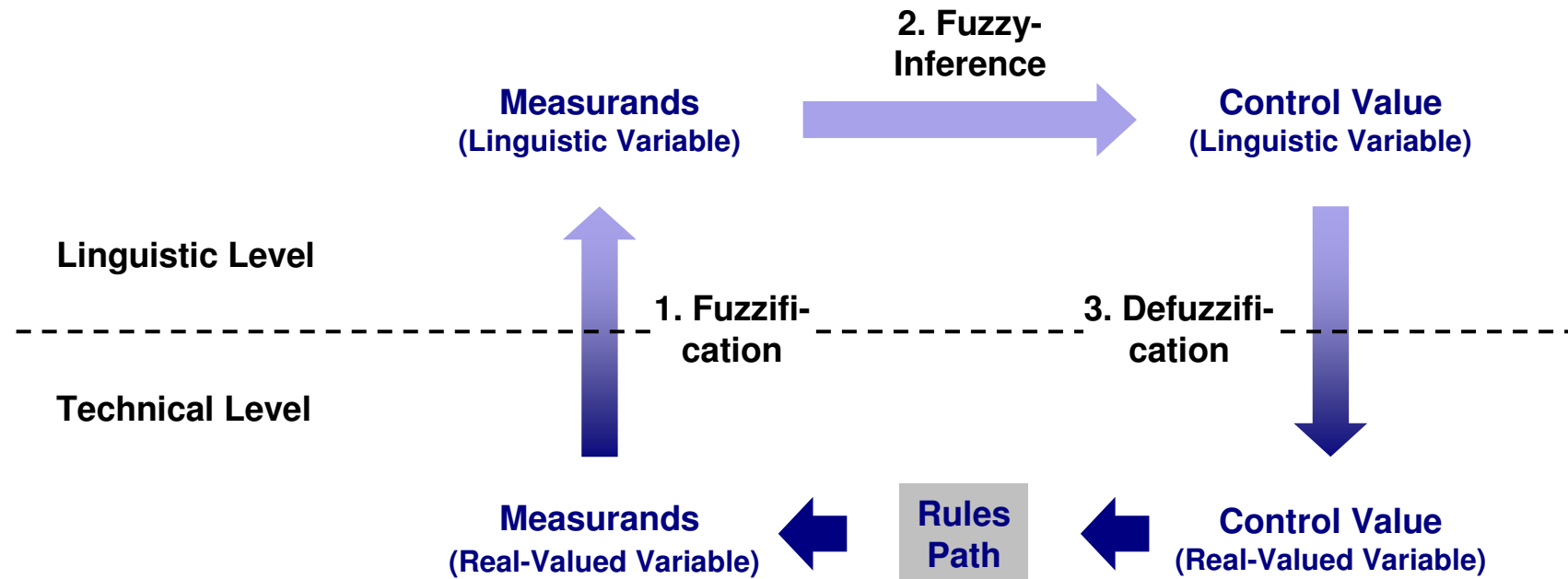
Linguistic Variables

- ⚡ Linguistic variables adopt expressions in natural language – so-called linguistic terms – as values
- ⚡ A *linguistic variable* is a quintuple (X, T, Ω, G, B) .
 - X : Name of the linguistic variable
 - T : Set of linguistic terms for X
 - Ω : Basic set
 - G : Set of syntactic rules for generating the term set T
 - B : Set of semantic rules, every element $x \in T$ is mapped to its meaning $B(x)$ in terms of a fuzzy set in Ω

Linguistic Variable "Order Value"



Fuzzy Systems

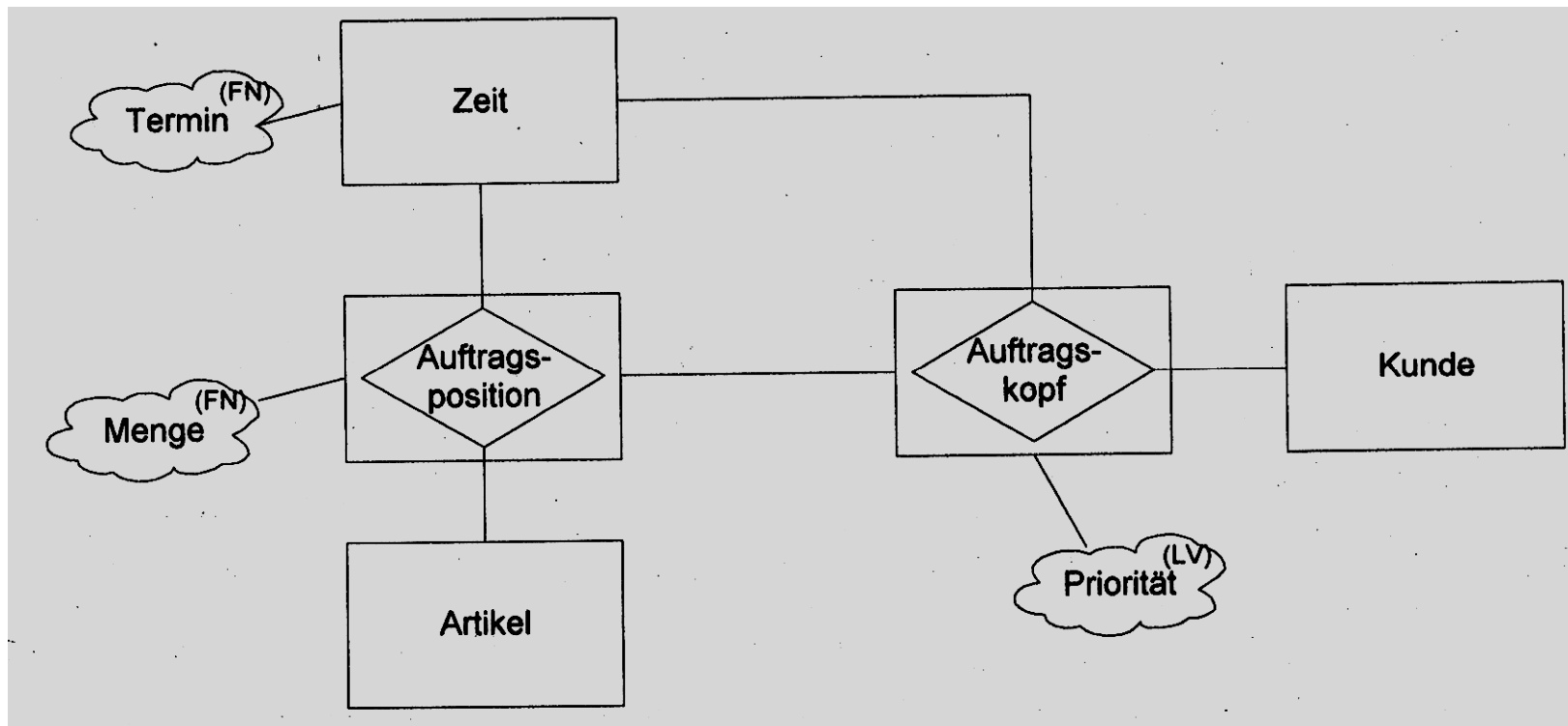


- /// *Fuzzification:* Representation of crisp values on fuzzy sets
- /// *Fuzzy-Inference:* A fuzzy system consists of input and output variables, whose respective attributes are connected by rules, consisting of a premises and a conclusion. The input and output variables are assigned to one another by way of an inference procedure.
- /// *Defuzzification:* For an executable action, for example: “set priority”, a crisp value from the output variable is required. A defuzzification step provides this crisp value.

Existing Approaches and Related Work

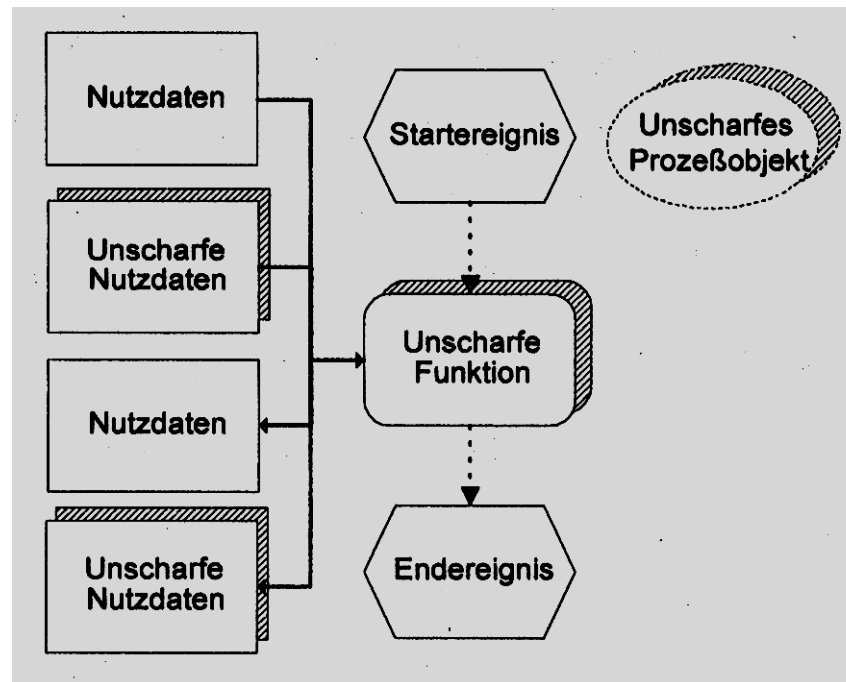
- /// Fuzzy-extension of the *Entity Relationship Model (ERM)*
[Zvieli, Chen 1986]
- /// Fuzzy theory-based extensions of object-oriented modelling methods for business processes
[Benedicenti et al. 1998; Cox 1999; Cox 2002]
- /// Object-oriented approach based on the fuzzy set theory for the simulation of business processes
Völkner, Werners [1998; 1999; Werners, Völkner 2000; 2000; 2002]
- /// The *Fuzzy Petri Net* results from the projection of several crisp Petri Nets, in which the structure information is represented as fuzzy sets
[Lipp 1982], Applications: [Lipp 1989; Lipp, Günther, Sonntag 1989; Valette, Cardoso, Dubois 1989; Cao, Sanderson 1991; Cardoso, Valette, Dubois 1991; Lipp 1991a; Lipp 1991b; Lipp 1991c; Cao, Sanderson 1992; Chun, Bien 1992; Eversheim, Lipp, Lehmann 1992; Günther, Lipp 1993; Srinivasan, Gracanin 1993; Richter 1994; ...]
- /// Consideration of fuzzy data in business process modelling with *Event-driven Process Chains* using the example of industrial order processing.
[Becker, Rehfeldt, Turowski 1996; Rehfeldt, Turowski 1996; Becker et al. 1997; Becker, Rehfeldt, Turowski 1997; Rehfeldt 1998]

Example: Fuzzy Attributes within the Entity Relationship Model (ERM)



Source: Rehfeldt, Markus: Koordination der Auftragsabwicklung : Verwendung von unscharfen Informationen. Wiesbaden : Dt. Univ.-Verl. [u.a.], 1998 (Gabler Edition Wissenschaft). – Zugl.: Münster (Westfalen), Univ., Diss., 1997 (in German)

Example: Vagueness in the Process View



Source: Rehfeldt, Markus: Koordination der Auftragsabwicklung : Verwendung von unscharfen Informationen. Wiesbaden : Dt. Univ.-Verl. [u.a.], 1998 (Gabler Edition Wissenschaft). – Zugl.: Münster (Westfalen), Univ., Diss., 1997 (in German)

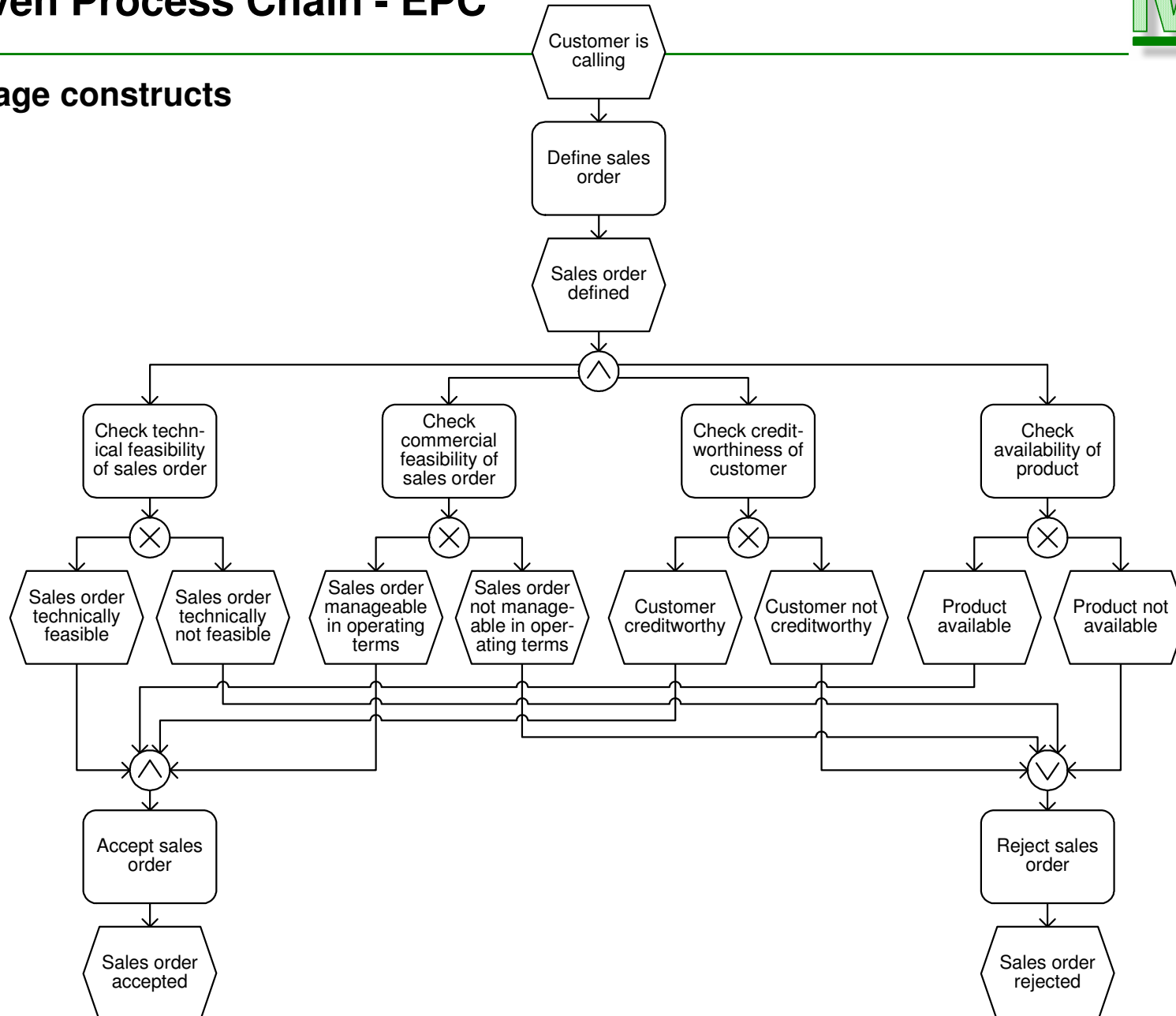
Intermediate Result

- /// Only rudimentary approaches which go into the aspects and requirements of a universal integration of fuzziness in business process modelling exist
- /// *In fact:* The possibilities for the integration of fuzziness in information modelling are limited by the existing approaches which demand completeness and precision
- /// The few approaches mentioned limit themselves to the graphic representation or textual notation of “fuzzy” modelling
- /// A scientific discussion about the “extension” of reference models using fuzzy aspects, as well as the enterprise-specific adaptation of reference models has not yet been held
- /// A corresponding tool support also does not exist

Event-driven Process Chain - EPC



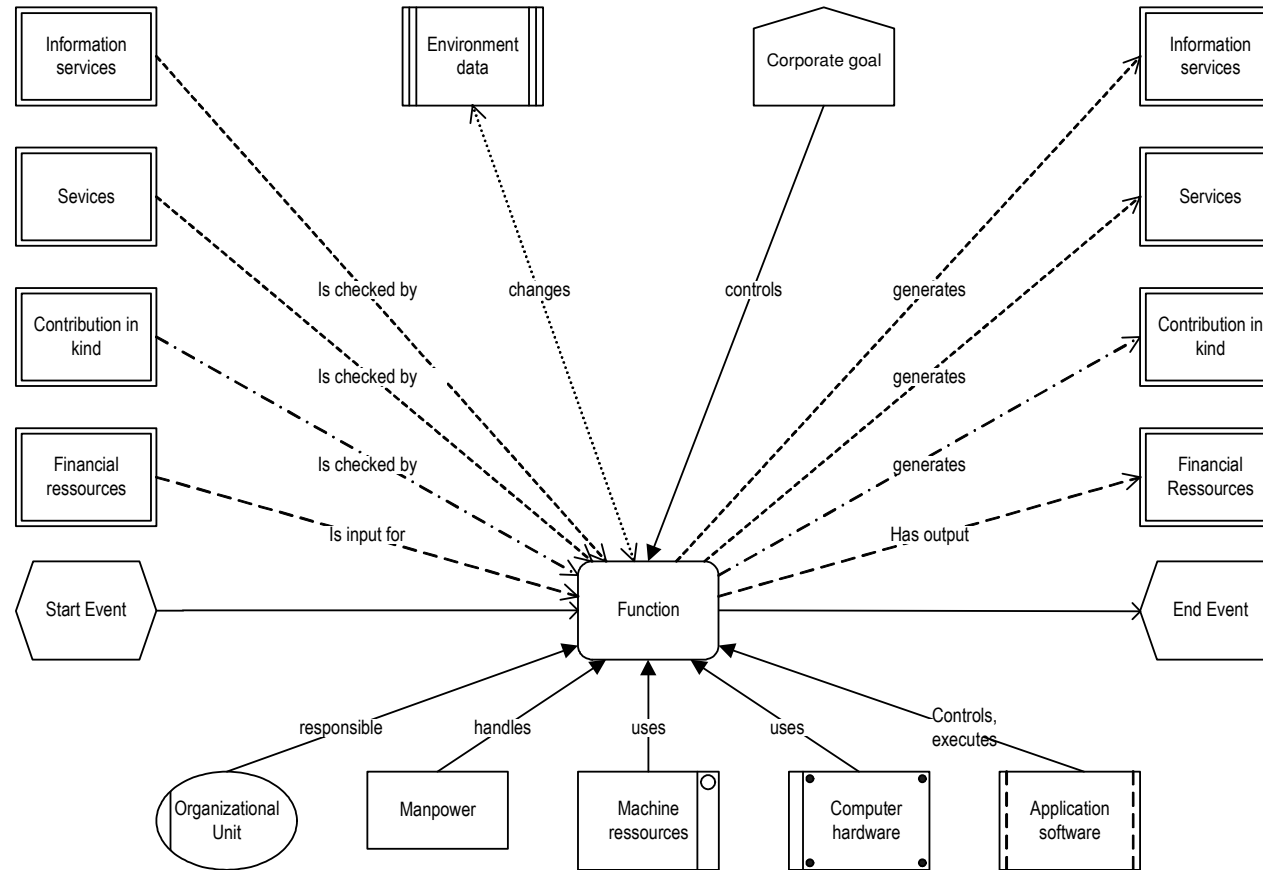
Basic language constructs



Process Modeling with the EPC



Extension with ARIS language constructs



Caption

→	Organization/ ressource flow	----->	Information services flow
→	Control Flow	- · - · - · >	Contribution in kind flow
·····>	Information Flow	- - - - ->	Financial resources flow



Basic EPC = (E, F, C, A)

EPC = (E, F, C, A, O, D, L, R)

E set of event, F set of function, C set of logical connector, A set of edges

O set of organisational units, D set of data object, L set of inputs/outputs

R set of relations restricting the assignment of elements of F to O, D, and L

Basic EPC = (E, F, C, A)

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E set of event, F set of function, C set of logical connector, A set of edges

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FEPC = (E, F, C, A, O, D, L, R, M, FC)

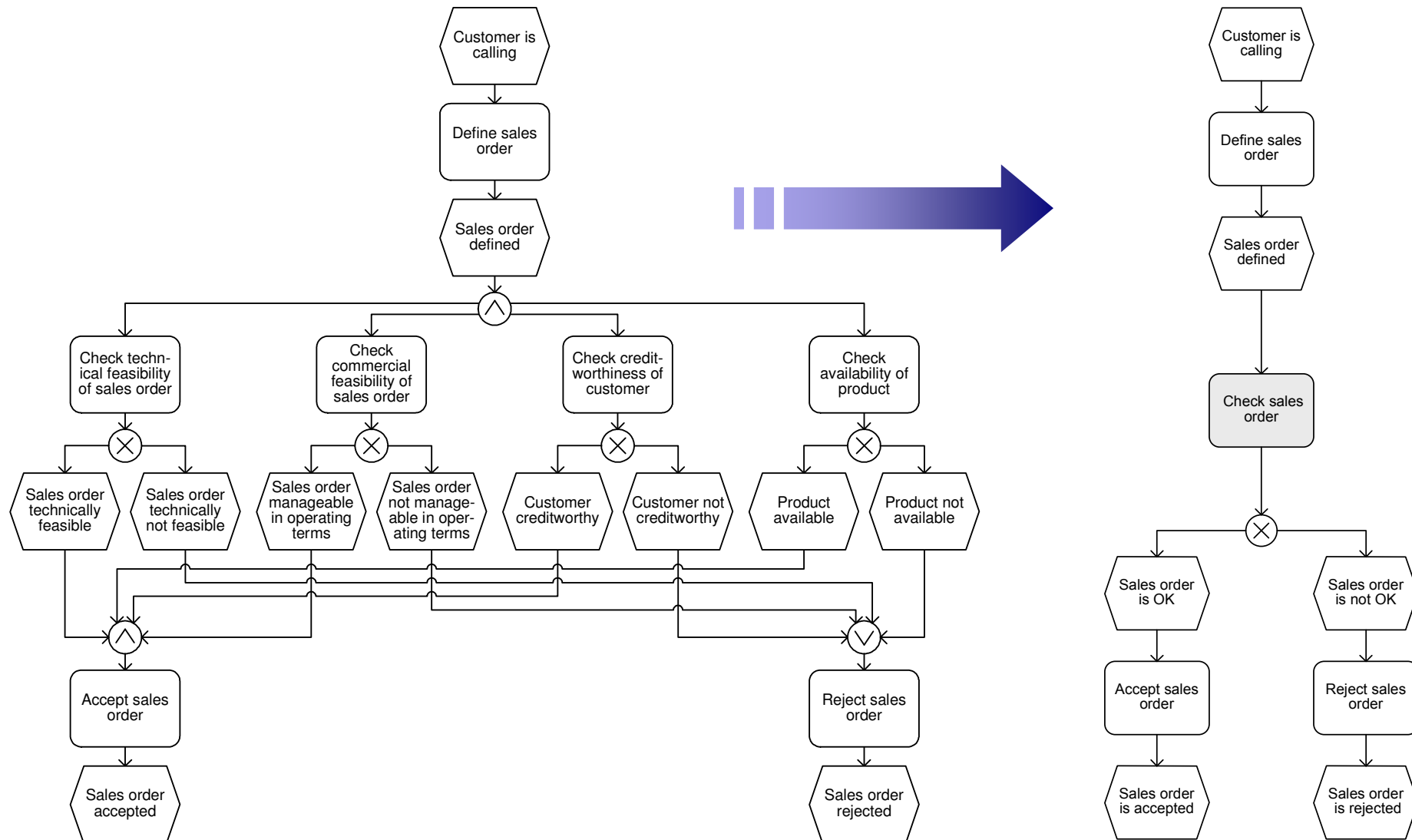
M set of attributes combined to elements of E, F, O, D, and L

FC set of Fuzzy Systems

Fuzzy Event-driven Process Chain



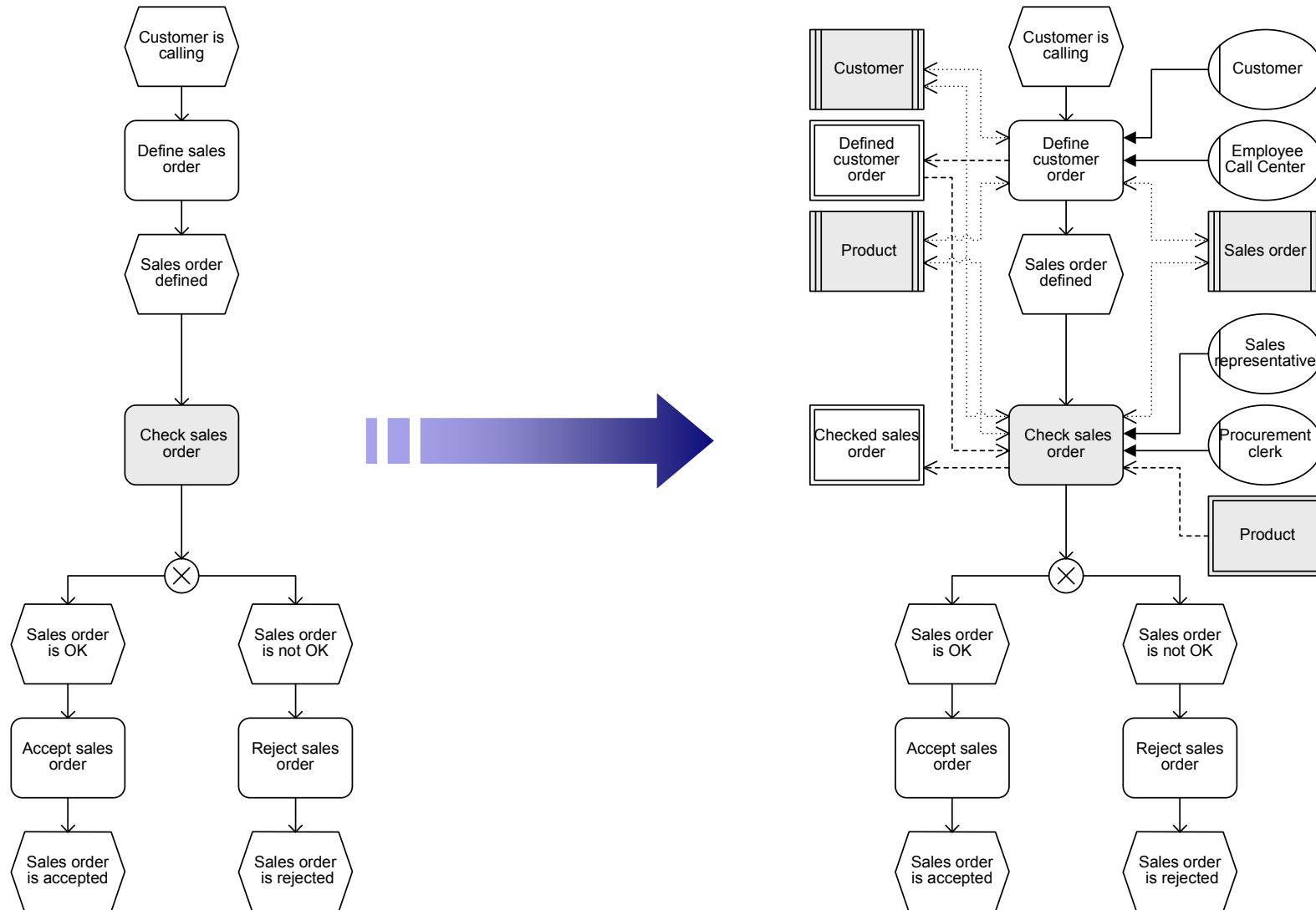
Extraction of rule knowledge (Built-Time and Run-Time)



Fuzzy Event-driven Process Chain



Extension with attributes und integration of ARIS-views



Fuzzy Modelling Tool



The screenshot displays the Fuzzy Modeling Tool interface. The main workspace shows a process flow diagram with nodes for 'Customer', 'Define sales order', 'Sales order defined', 'Check sales order', and 'Sales order rejected'. The 'Attributes' window is open, showing a graph for the linguistic variable 'Order size' with terms: very low, low, medium, high, very high. The x-axis is 'Order size in 1000 €' (0 to 10) and the y-axis is membership degree (0.0 to 1.0). The 'Rules' window shows a table of fuzzy rules.

IF		THEN
Customer rating	Order size	Sales order rating
low	very low	low
low	low	low
low	medium	low
low	high	medium
low	very high	medium
medium	very low	low
medium	low	low
medium	medium	medium
medium	high	medium
medium	very high	high
high	very low	low
high	low	medium
high	medium	medium



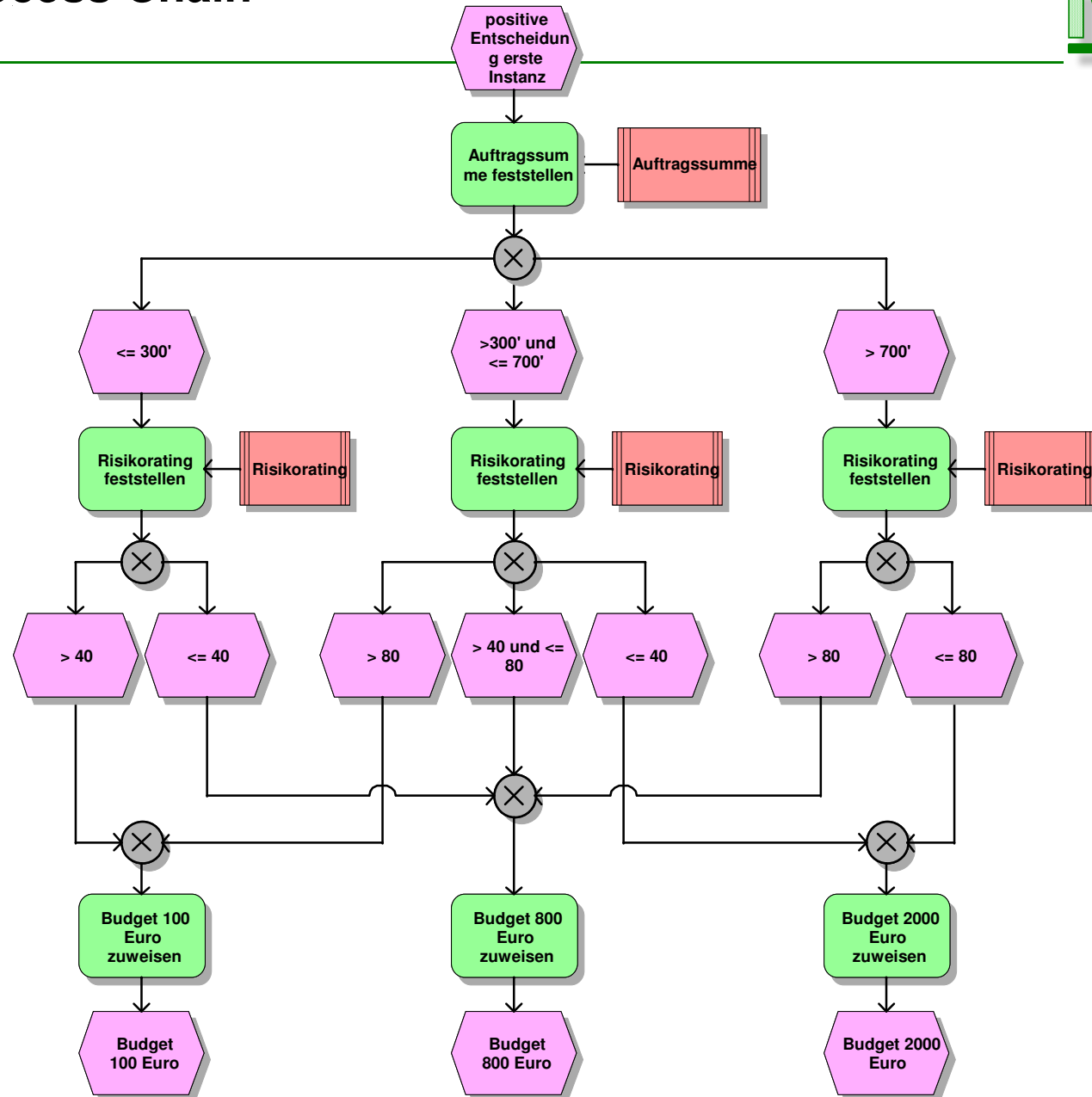
Case: Loan Granting



/// Granting Procedure depending on Loan Volume and Risk Rating

		Loan Volume		
		und ≤ 300.000 € (klein)	> 300.000 € und ≤ 700.000 € (mittel)	> 700.000 € (groß)
Risk Rating	> 80 (gut)	100 € (Kleinkredit- entscheidung)	100 € (Kleinkredit- entscheidung)	800 € (Routine- entscheidung)
	> 40 und ≤ 80 (normal)	100 € (Kleinkredit- entscheidung)	800 € (Routine- entscheidung)	2000 € (Sonderprüfung)
	≤ 40 (schlecht)	800 € (Routine- entscheidung)	2000 € (Sonderprüfung)	2000 € (Sonderprüfung)

Event-Driven Process Chain Loan Granting

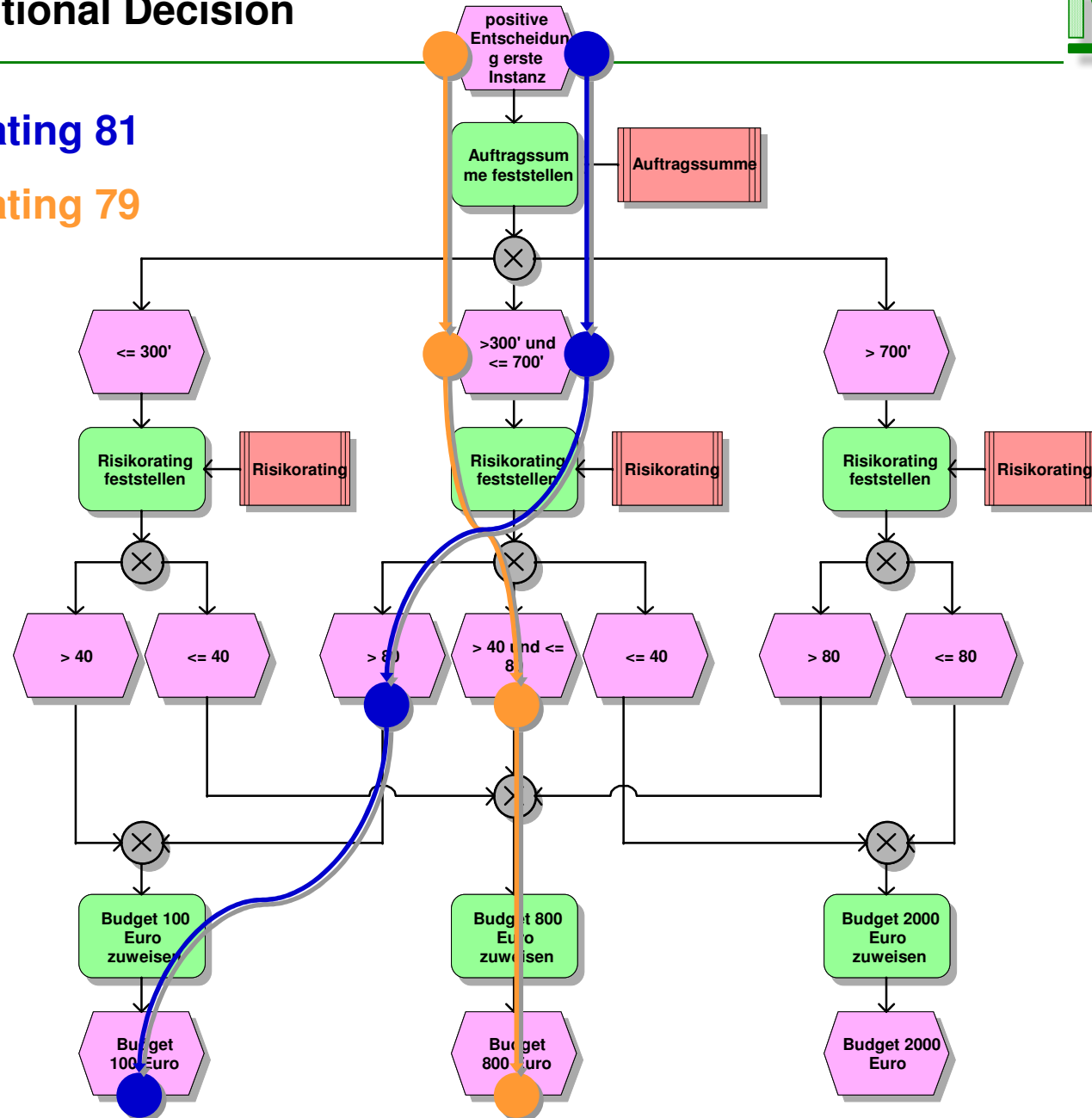


Shortcoming of traditional Decision



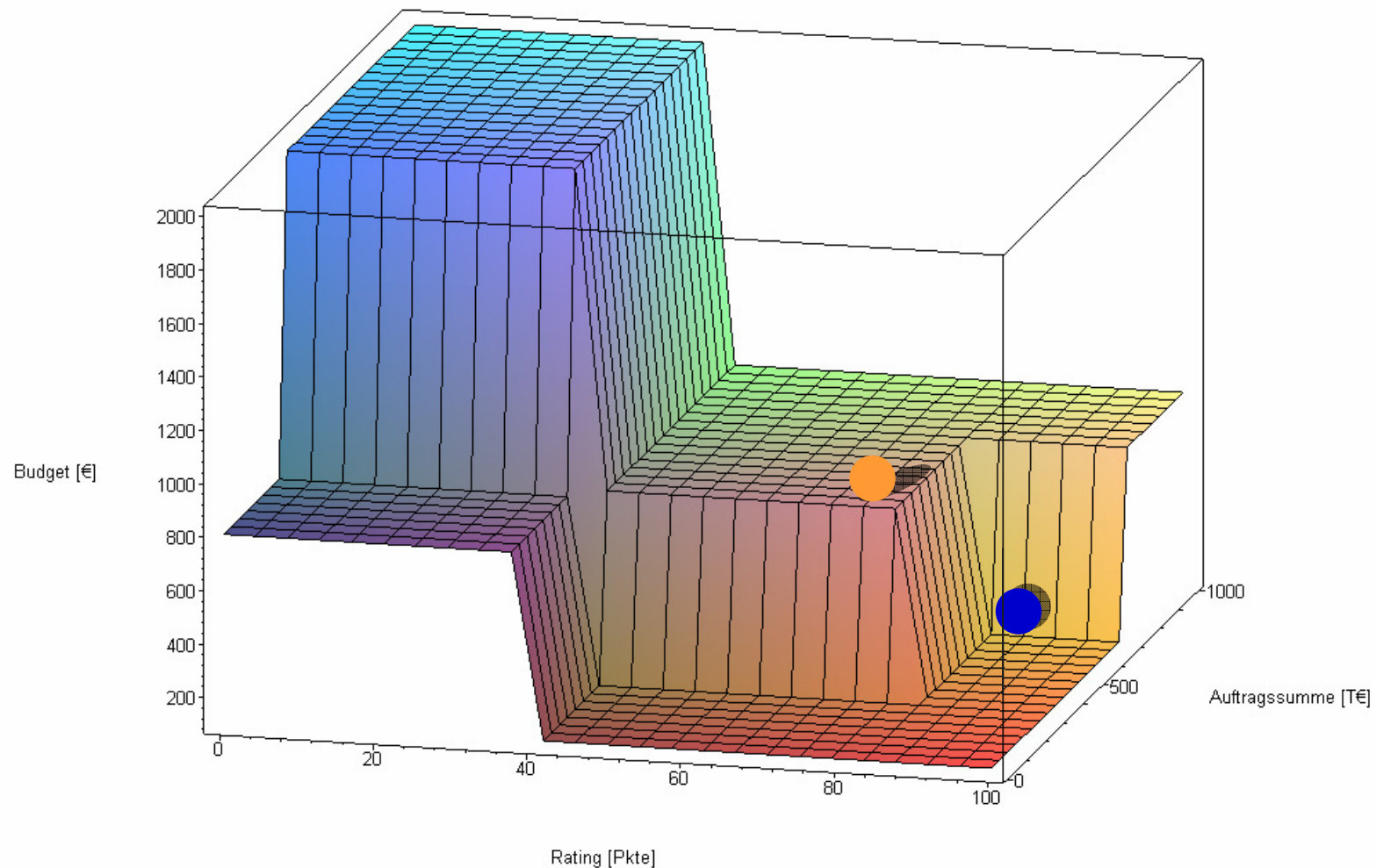
● Case A: 700' €, Rating 81

● Case B: 301' €, Rating 79

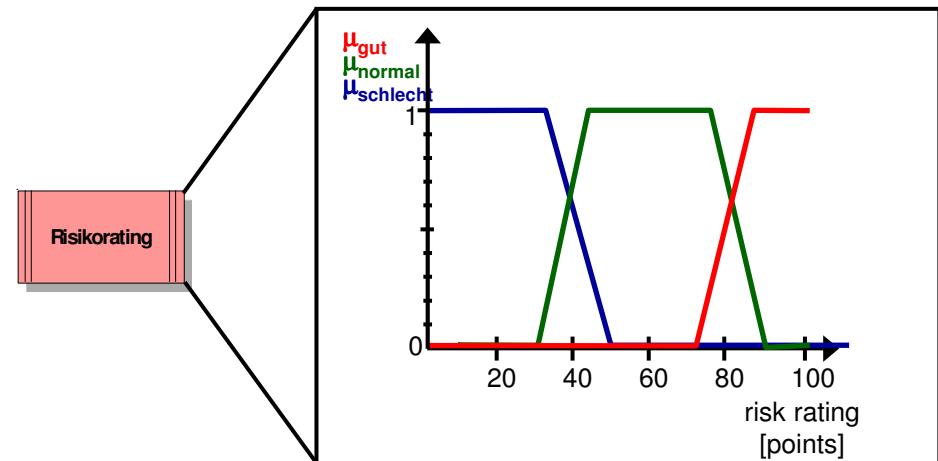
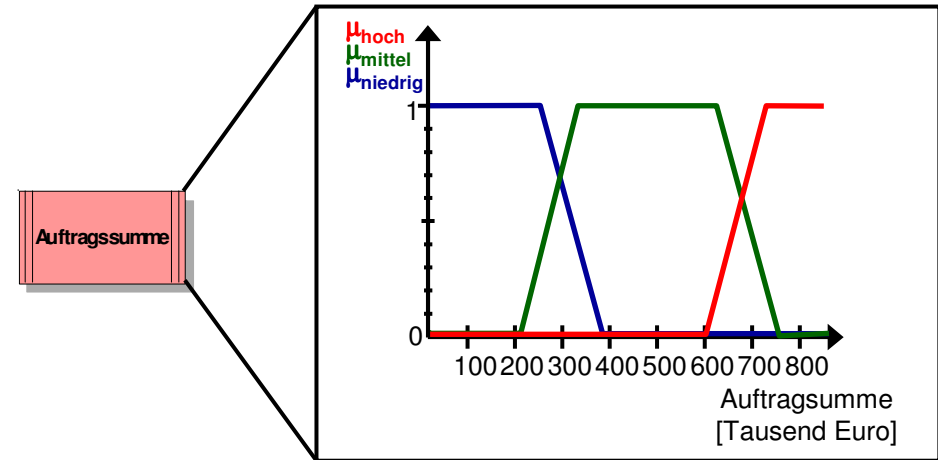
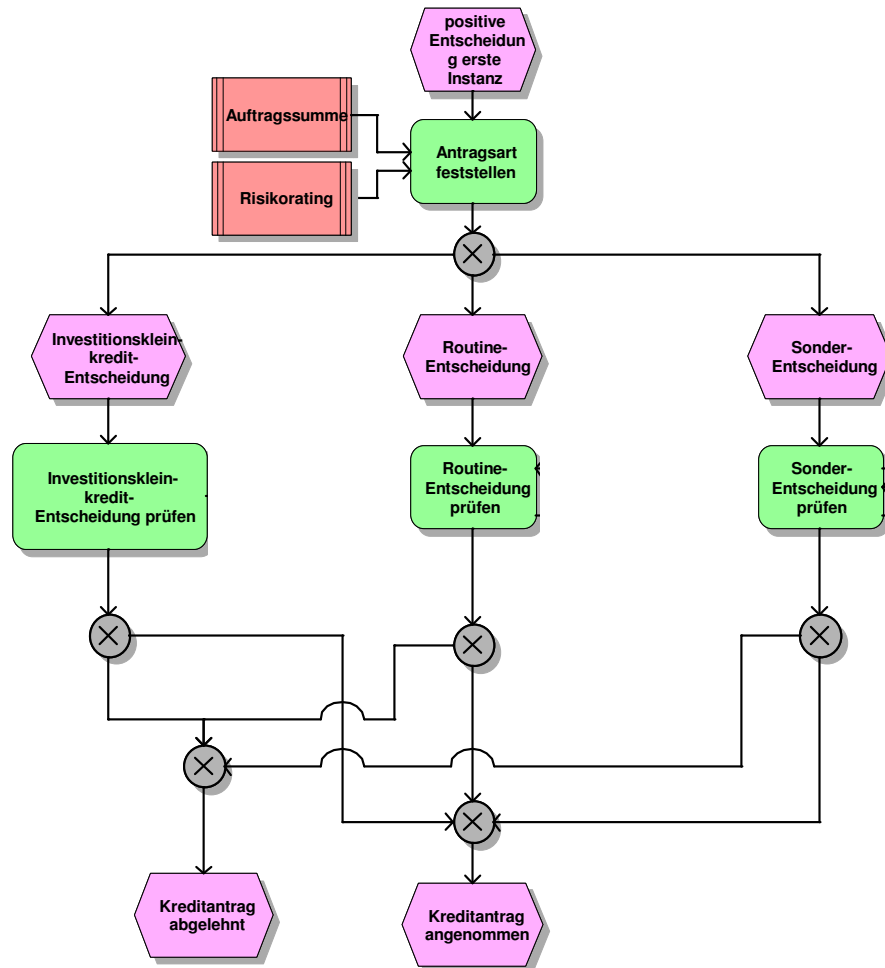


Case A: 700' €, Rating 81

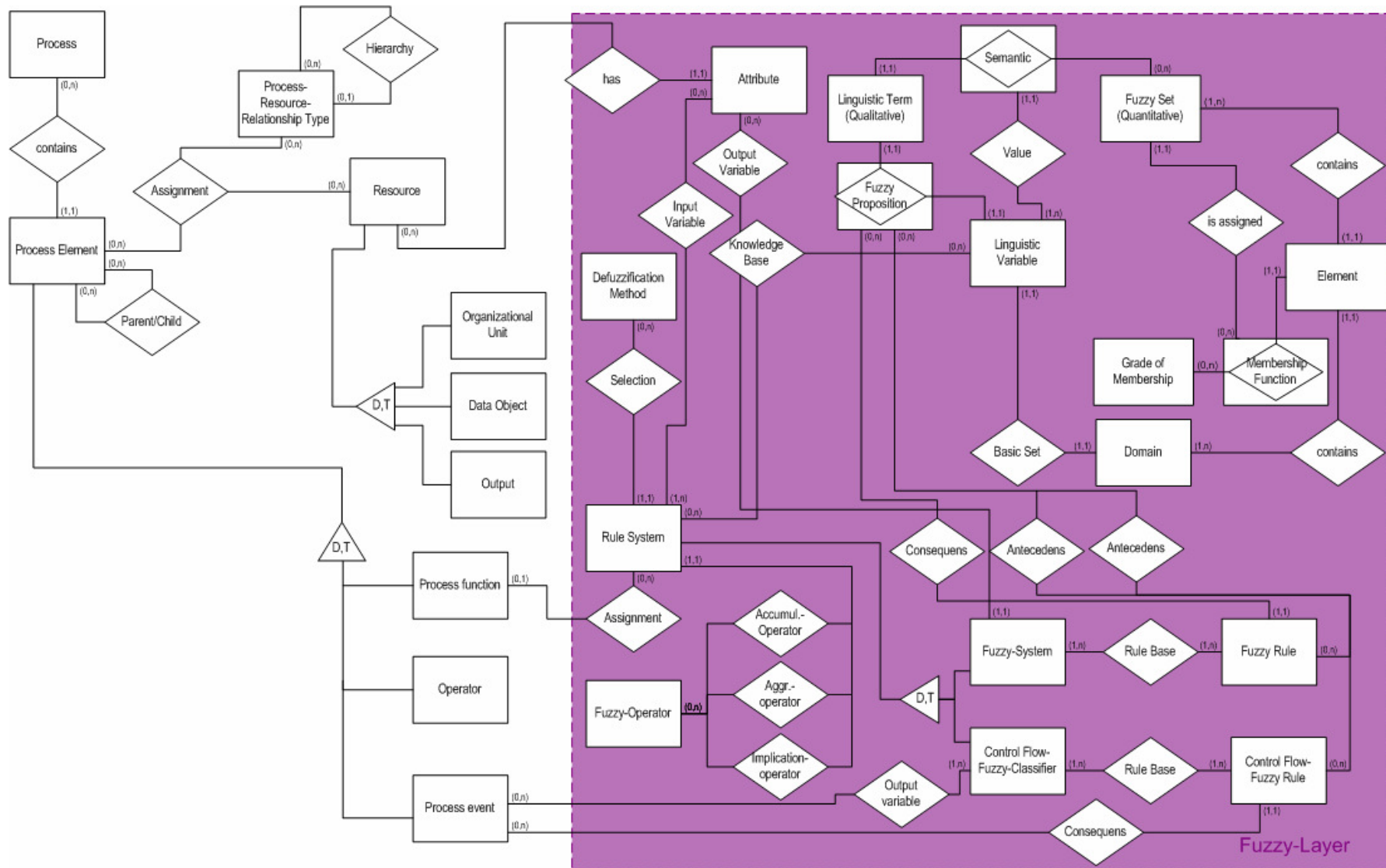
Case B: 301' €, Rating 79



Fuzzy Event-driven Process Chain



Meta-Model of Fuzzy Event-Driven Process Chain



- ⑥ **Only minor differences between output of simple fuzzy systems and complex crisp model**

- ⑥ **Flexibility of Fuzzy-Systems by robustness and adaptability**

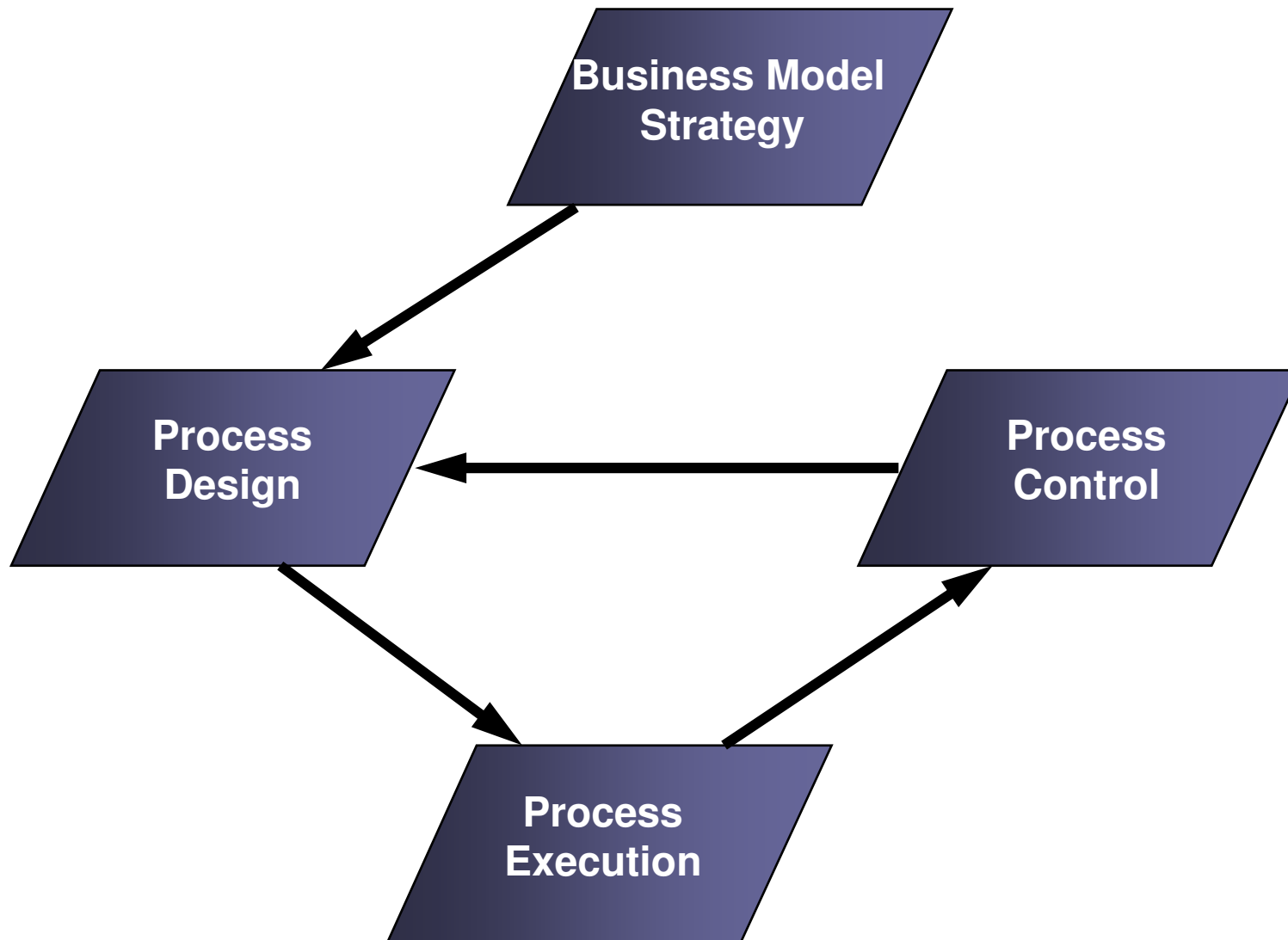
- ⑥ **Similar to human way of thinking**

- ⑥ **If-Then-Rules easy to understand**

- ⑥ **Rule base can be maintained by user**

- **A Fuzzy System can support a business process at least as good as a crisp system with less efforts and in a user-centered way.**

Life Cycle of Business Processes



Main Topics

- /// Vagueness in business process models
- /// Extending business process modelling through fuzzy technology
- /// Fuzzy Event-driven process chains

Future Challenges

- /// Extension of process- and organisational aspects through fuzzy technology
- /// Formalisation of the fuzzy extension of the EPC
- /// Establishing standards to include fuzzy-values in process description
- /// Implementation of a tool for fuzzy enterprise modelling