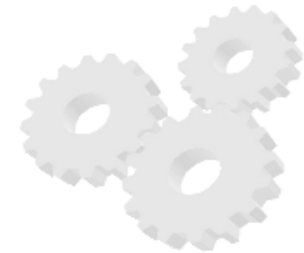
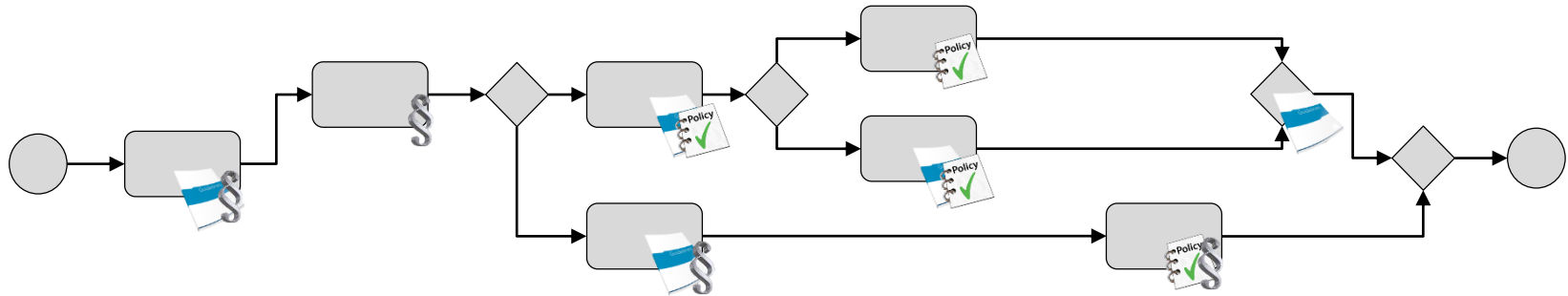


CHECKING BUSINESS PROCESS MODELS FOR COMPLIANCE

COMPARING GRAPH MATCHING AND TEMPORAL LOGIC

BUSINESS PROCESS MANAGEMENT

COST REDUCTION, COMPLIANCE, EFFICIENCY



Sources: Becker & Kahn (2011), Ghose and Koliadis (2007), Hammer (2010), Rinderle-Ma et al. (2008), Sadiq et al. (2007)

PATTERN DEVELOPMENT



PATTERN STRUCTURE - TEXT ANALYSIS

- 1. *“The process of granting loans encompasses the **necessary operational steps up to the loan payout**. All factors which are material for assessing the risk shall be analyzed and assessed, taking particular account of the debt-servicing capacity of the borrower or the property/project, with the intensity of the assessment depending on the riskiness of the exposures (eg creditworthiness assessment, risk score in the risk classification procedure or an assessment based on a simplified procedure).*
- 2. *As a general rule, the **value and legal validity of collateral shall be reviewed prior to granting the loan**. When reviewing the value of collateral, available collateral values may be relied on if there are no indications of any change in value.*
- 3. *If the collateral value depends largely on the situation of a third party (eg a guarantee), the third party’s counterparty and credit risk shall be appropriately reviewed.*
- 4. *The institution shall define the eligible types of collateral and the procedures for determining the value of this collateral.”*

Federal Financial Supervisory Authority - (BaFin)Circular 10/2012: Minimum Requirements for Risk Management (MaRisk BA) - BTO 1.2.1 - Granting of loans

PATTERN DEVELOPMENT



PATTERN CONTENT - TEXT ANALYSIS

- 1. “The process of granting loans encompasses the necessary operational steps **up to the loan payout**. All factors which are material for assessing the risk shall be **analyzed and assessed**, taking particular account of **the debt-servicing capacity** of the borrower or the property/project, with the intensity of the assessment depending on the riskiness of the exposures (eg creditworthiness assessment, risk score in the risk classification procedure or an assessment based on a simplified procedure).
- 2. As a general rule, the **value and legal validity of collateral shall be reviewed** prior to granting the loan. When reviewing the value of collateral, available collateral values may be relied on if there are no indications of any change in value.
- 3. If the collateral value depends largely on the situation of a third party (eg a guarantee), the **third party’s counterparty and credit risk** shall be appropriately reviewed.
- 4. The institution shall define the eligible types of collateral and the procedures for determining the value of this collateral.”

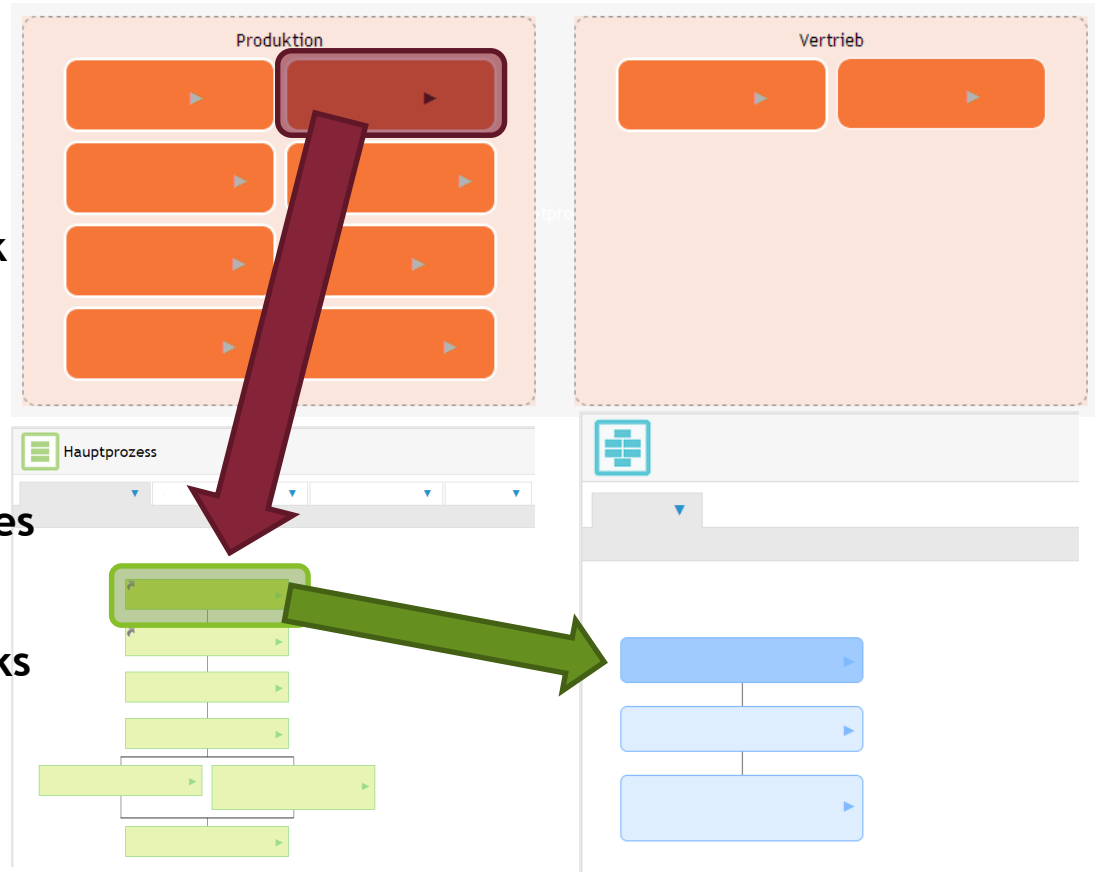
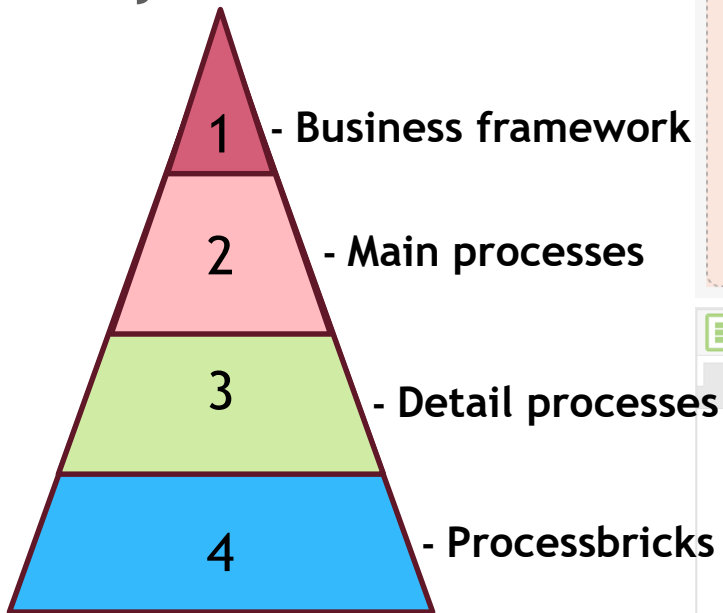
Federal Financial Supervisory Authority - (BaFin) Circular 10/2012: Minimum Requirements for Risk Management (MaRisk BA) - BTO 1.2.1 - Granting of loans

PROVIDED MODELS

ICEBRICKS MODELLING NOTATION

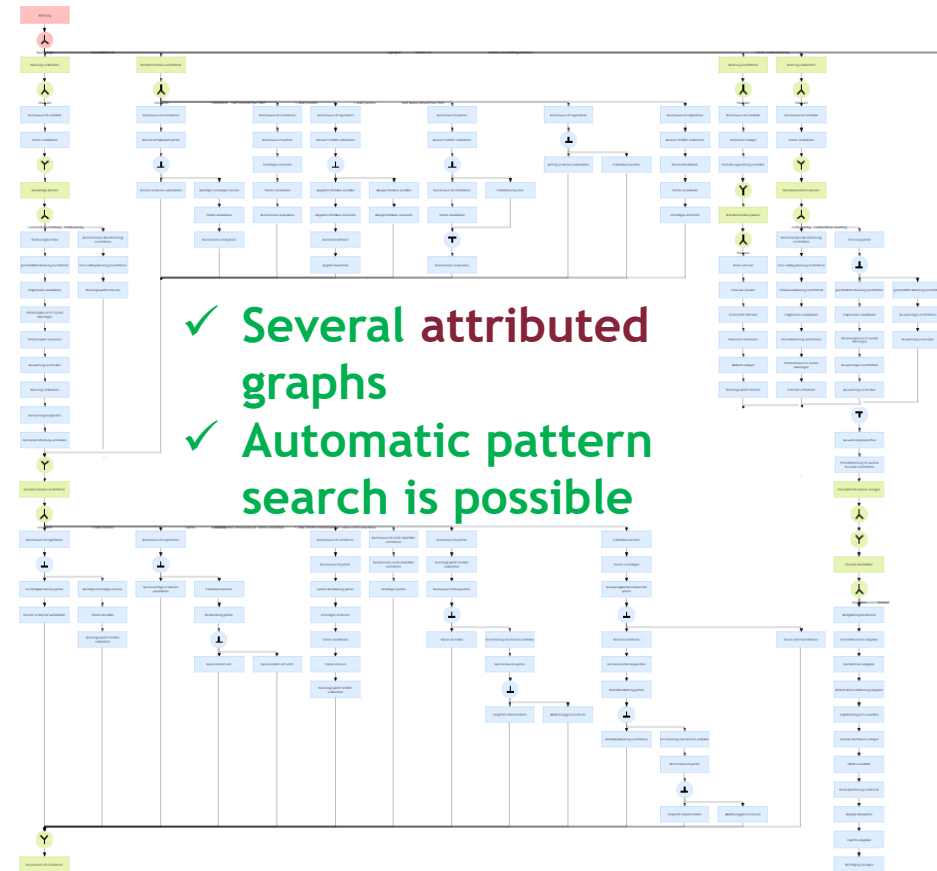
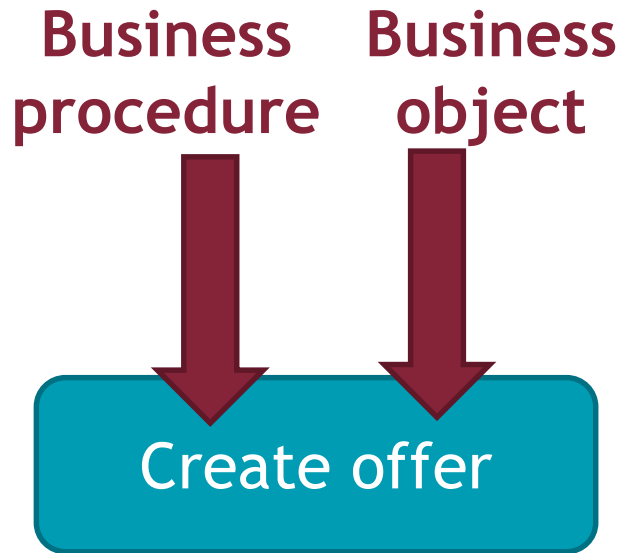


4-Layer Architecture:



PROVIDED MODELS

ICEBRICKS MODELLING LANGUAGE AND ICEBRIDGE PLUGIN

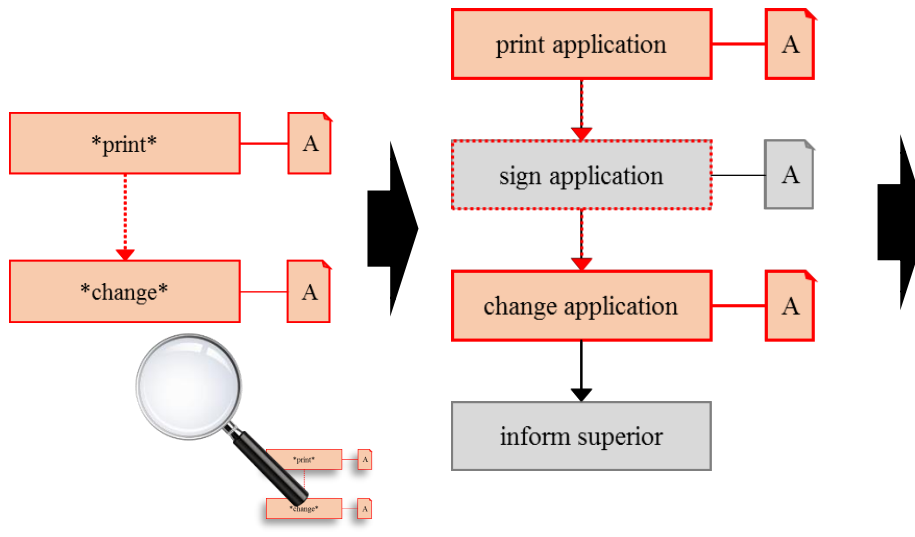


PROCESS QUERYING

PROCEDURE



“A printed document must not be changed.”



Legislation text

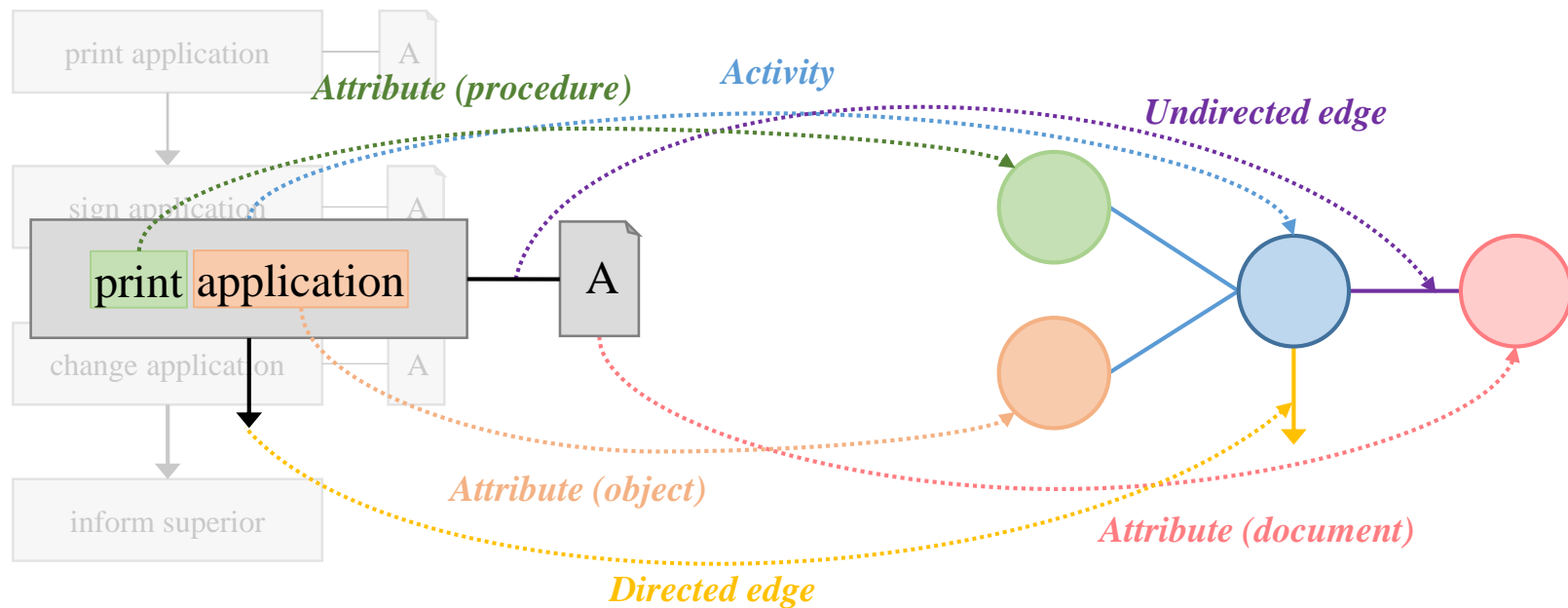
Compliance pattern

Process model

Result

PROCESS QUERYING

GRAPH-THEORETICAL POINT OF VIEW



GRAPH BASED PATTERN MATCHING

FINDING ELEMENTS OF A SPECIFIC TYPE



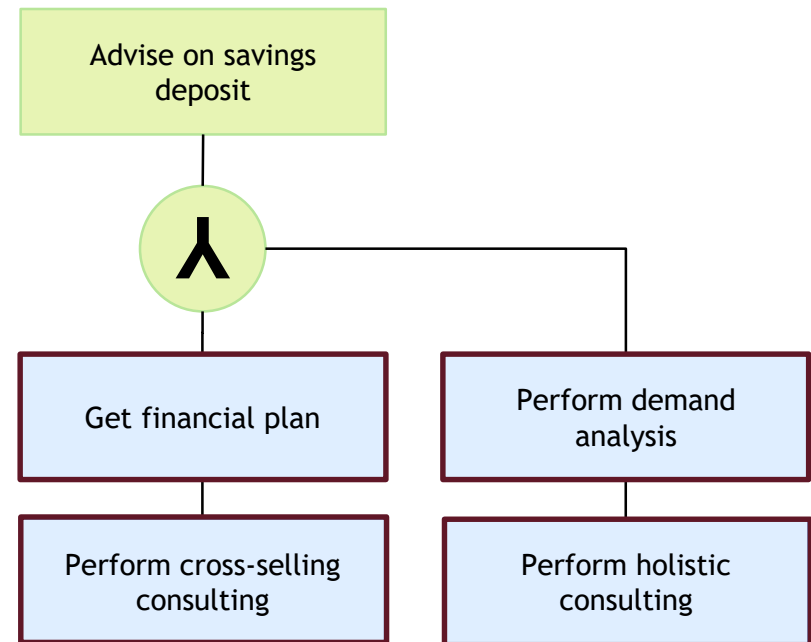
▪ Evaluate function $ElementsOfType(E, T)$

$e = \{ \text{Advise on savings deposit}, \text{Person}, \text{Get financial plan}, \text{Perform demand analysis}, \text{Perform holistic consulting}, \text{Perform cross-selling consulting} \}$

$t = \text{"Processbrick"}$

$ElementsOfType(e, \text{"Processbrick"})$

$= \{ \text{Get financial plan}, \text{Perform demand analysis}, \text{Perform holistic consulting}, \text{Perform cross-selling consulting} \}$



GRAPH BASED PATTERN MATCHING

FINDING ELEMENTS WITH SPECIFIC ATTRIBUTE VALUES



- Evaluate $ElementsWithTypeAttributeOfValue(E, T, V)$

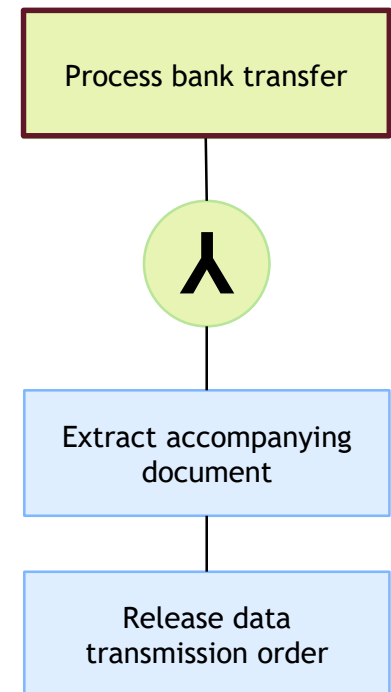
$e = \{ \text{Process bank transfer}, \text{Actor}, \text{Extract accompanying document}, \text{Release data transmission order} \}$

$t = \text{Caption}$

$v = \text{"Process bank transfer"}$

$ElementsWithTypeAttributeOfValue(e, t, v)$

$= \{ \text{Process bank transfer} \}$

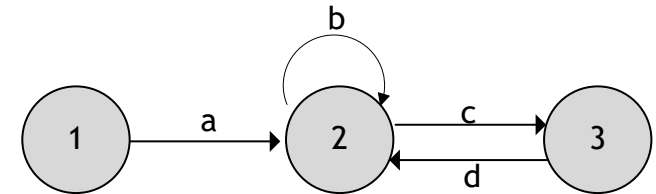


PROCESS QUERYING

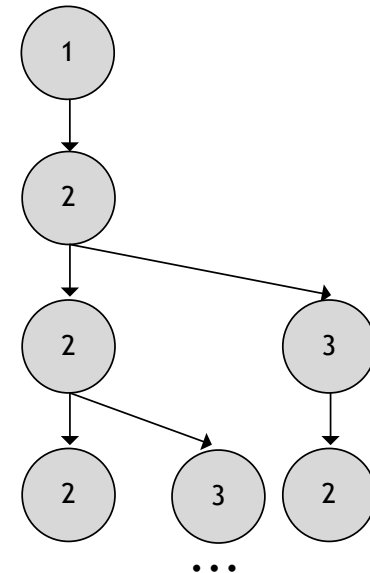
TEMPORAL-LOGIC POINT OF VIEW



- Symbolic Model Checking (SMC):
Model processes as state-machines



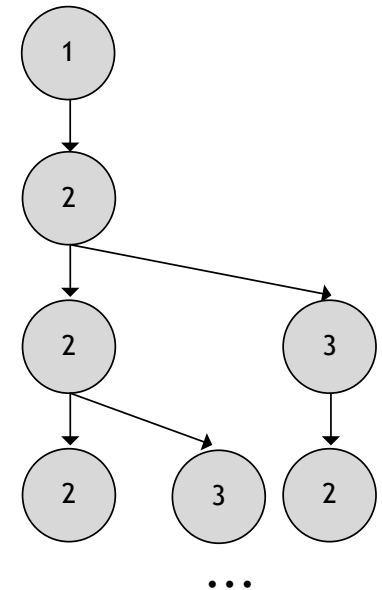
- Computation Tree Logic (CTL):
Computations on tree-like structure
of all states/paths,
where future is nondeterministic



CTL

PATTERN SPECIFICATION

- Linear temporal operators:
 - $G(p)$ — p holds in every state on the path
 - $F(p)$ — p holds in some state on the path
 - ...
- Path quantifiers:
 - **A**: for all paths from a state
 - **E**: for some path(s) from a state
- Combining: AG, EG, AF, EF

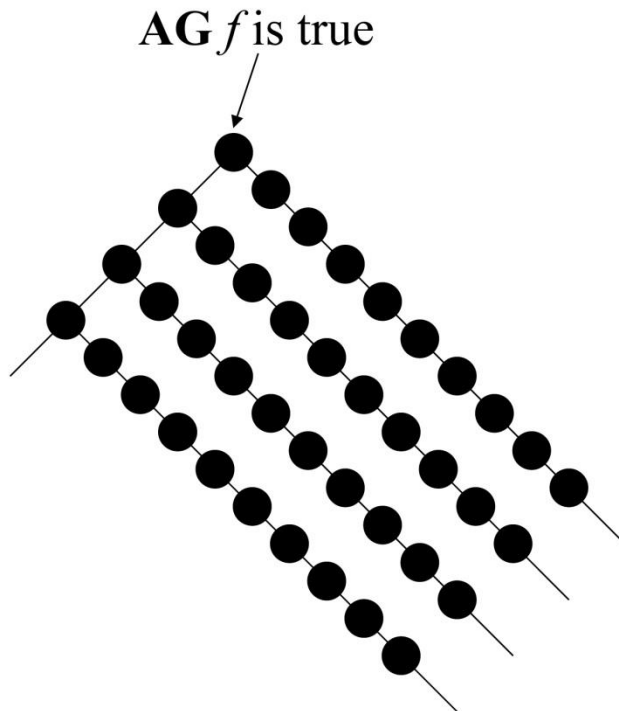


CTL

PATTERN SPECIFICATION



- $AG(p)$ — p holds on every path in every state
- $EG(p)$ — p holds on some path in every state



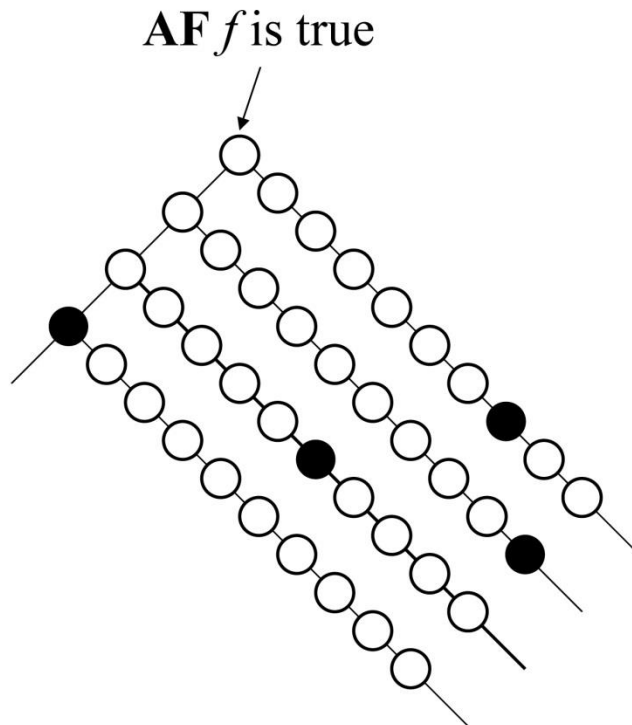
Source: Zheng, H. (2006)

CTL

PATTERN SPECIFICATION



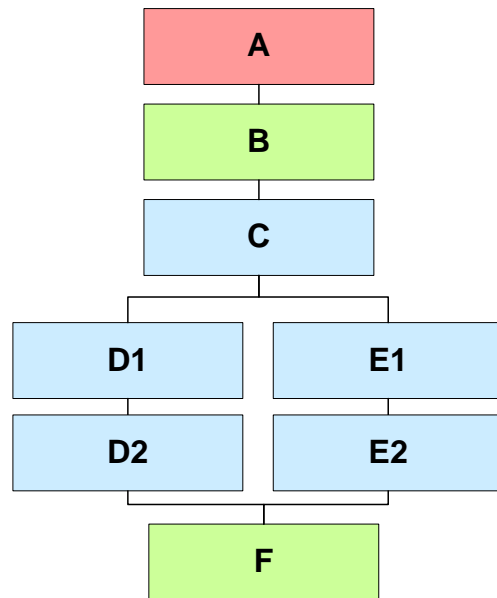
- $AF(p)$ — p holds on every path in some state
- $EF(p)$ — p holds on some path in some state



Source: Zheng, H. (2006)

PRE-TRANSFORMATION OF MODELS

ICEBRICKS EXECUTION SEMANTICS



FOUR EXEMPLARY PATTERNS



- Infringement Pattern
- Too Many Routing Paths per Element
- Check Documents Repetitively
- Observe Iteration Efficiency

INFRINGEMENT PATTERN



„Before account transactions are made, the legal documents have to be handed out to the customer.“

GMQL pattern from Becker et al. (2013)

INFRINGEMENT PATTERN



DPNCE (
UNION (EWAOV (O, 'Caption', 'Consult customer'),
EWAOV (O, 'Caption', 'Talk to customer')),
UNION (EWAOV (O, 'Caption', 'Make account transaction'),
EWAOV (O, 'Caption', 'Perform account transaction')),
UNION (UNION (
EWAOV (O, 'Caption', 'Hand out contract'),
EWAOV (O, 'Caption', 'Hand out documents')),
EWAOV (O, 'Caption', 'Hand out preliminary contract'))))

GMQL

$M, s_0 \models AG ((\text{“Consult customer”} \vee \text{“Talk to customer”} \rightarrow$
 $AG (
EG (\neg \text{“Make account transaction”} \wedge \neg \text{“Perform account transaction”}) \vee$
 $A [\neg \text{“Make account transaction”} \wedge \neg \text{“Perform account transaction”}] \cup$
 $(\text{“Hand out contract”} \vee \text{“Hand out documents”} \vee \text{“Hand out preliminary contract”})))$

CTL

GMQL pattern from Becker et al. (2013)

TOO MANY ROUTING PATHS PER ELEMENT



„For each process split there should be no more than three routing paths.“

Textual pattern from Delfmann & Höhenberger (2015)

TOO MANY ROUTING PATHS PER ELEMENT



COMPLEMENT (O,
UNION (
UNION (EWNSR (O, 0), EWNSR (O, 1)),
EWNSR (O, 2)))

GMQL

Not possible, because counting pre- or succeeding elements is not supported by CTL.

CTL

Textual pattern from Delfmann & Höhenberger (2015)

CHECK DOCUMENTS REPETITIVELY



„Documents should not be repetitively checked
and analysed in a loop.“

CHECK DOCUMENTS REPETITIVELY



DLCE (O,
UNION (
EWAOV (O,'Caption','Check document'),
EWAOV (O,'Caption','Analyse document'))))

GMQL

$M, s0 \models AG ((\text{“Check document”} \vee \text{“Analyse document”}) \rightarrow$
 $AG (\neg \text{“Check document”} \wedge \neg \text{“Analyse document”}))$

CTL

OBSERVE ITERATION EFFICIENCY



„Iterations should be efficient, i.e., in an exception handling loop it should not be checked again if an exception needs to be handled.“

OBSERVE ITERATION EFFICIENCY



```
DLNCE (O,  
  UNION (  
    EWAOV (O, 'Caption', 'Check if exception handling necessary'),  
    EWAOV (O, 'Caption', 'Check for exception handling'))))
```

GMQL

Not possible, because the pattern requires the identification of loops as a basis to check the other conditions, which is not supported by CTL.

CTL

COMPARISON OF THE APPROACHES



Criterion	GMQL	CTL
Approach-specific		
Need for model transformation	Transformation to graph	Transformation to automata
Visualization of query results	Graphical visualization	None
Query-specific		
Specification of queries	Set-based operations	Logical formulas
Attributes for model elements	Directly supported	Need to be modelled as labels
Result of query execution	Number of pattern occurrences	Boolean result (true/false) Counterexample
Feature-specific		
Count ingoing or outgoing edges	Supported	Not Supported
Differ between directed and undirected edges	Supported	Not Supported
Identify loops with additional constraints	Supported	Not Supported



DENNIS RIEHLE

DENNIS.RIEHLE@ERCIS.UNI-MUENSTER.DE

THE IS RESEARCH NETWORK

www.ercis.org