

# Event-driven Reactivity

## A Survey and Requirements Analysis



SYSTEMATIC THOUGHT LEADERSHIP FOR INNOVATIVE BUSINESS

Kay-Uwe Schmidt, SAP

02.06.2008

Co-Authors:

Dakro Anicic, FZI

Roland Stühmer, SAP

# Agenda



1. **Introduction**
2. Survey of Event-triggered Reactivity
3. Requirements
4. Future Work

Event-driven processing becomes ever important in various application domains

- Ranging from traditional business applications, like supply-chain management
- To the entertainment industry, like on-line gaming applications

The market value should increase tenfold by 2010 and should reach something like \$4bn in total (IBM).

Key role of even-driven processing for making business more agile

Main benefit of "eventizing" business systems

- Event processing introduces a kind of reactive dynamics
- Enabling active responding on signals sensed/derived from the current context

Event-triggered Reactivity (EtR)

- Opens great opportunities for system/process improvements.

# Agenda



1. Introduction
- 2. Survey of Event-triggered Reactivity**
3. Requirements
4. Future Work

First mention of the ECA paradigm by U. Dayal, A. P. Buchmann, and D. R. McCarthy in 1988

- “Rules are objects too: A knowledge model for an active, object-oriented databasesystem”. In Lecture notes in computer science on Advances in object-oriented database systems, pages 129-143, New York, NY, USA, 1988. Springer-Verlag New York, Inc.
- This paper describes work in progress on the knowledge model (an extended data model that includes constructs for representing rules) of HiPAC, an active, object-oriented DBMS.

“Central to our knowledge model is the concept of *event-condition-action (ECA) rules*, which generalizes the many different mechanisms introduced previously in the literature to support active DBMS functions.

- The *event* part of an ECA rule specifies database operations, temporal events, or signals from arbitrary processes;
- the *condition* part specifies database queries;
- and the *action* part specifies a program.
- When the event occurs (is *signaled*, the condition is evaluated; if the condition is *satisfied*, the action is executed.”
- **ON** event **IF** condition **DO** action

The two kinds of event processing:

- Complex Event Processing (CEP)
- Event Stream Processing (ESP)

Dealing with different problems in event processing using different approaches

ESP – extraction of simple events from a stream

- Events are totally ordered by time
- Emphasis of ESP on efficiency for high throughput and low latency
- Algorithmic stock trading

CEP – extraction of complex event patterns from a cloud

- Only a partial temporal order of events
- Other partial order of interest for CEP is for instance causality
- More time and memory needed
- Business Process Monitoring

CEP is a superset of ESP

CEP and ESP nowadays adopt each others approaches

Development for active databases in the late 80's and early 90's

- use complex event specifications to facilitate database triggers
- not only listen to simple events but observe complex combinations of events until the trigger procedures are executed

Simple events carry a type, their occurrence time and possibly other parameters

Creation of complex nested expressions, using operators like And, Or, Sequence, and others

Complex events are detected from occurrences of one or more of simple or complex events

Structure of event patterns: event operators

A nested event operator might have several event types as arguments

An event detector for the given pattern functions as a stream pattern matcher and listens for events that satisfy the type constraints and together satisfy the semantics of the given operator, e.g. occurred in sequence

## Finite State Automata

- Ode 1992
- Transformation of complex event expressions into deterministic finite automata
- Convenient model to define the semantics of complex event operators
- Downside no acceptance of overlapping occurrences of the same complex event

## Colored Petri Nets

- SAMOS 1994
- Convenient model to define the semantics of complex event operators
- Also the detection of overlapping occurrences is possible

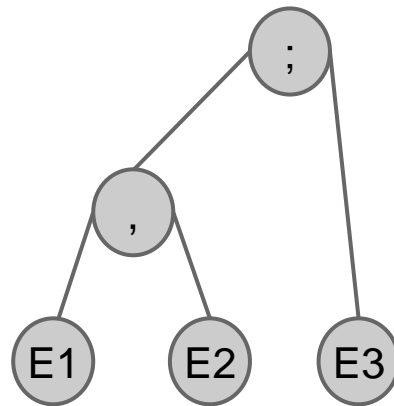
## Graph-based Approaches



Sentinel based on Snoop, SnoopIB in the mid 90's

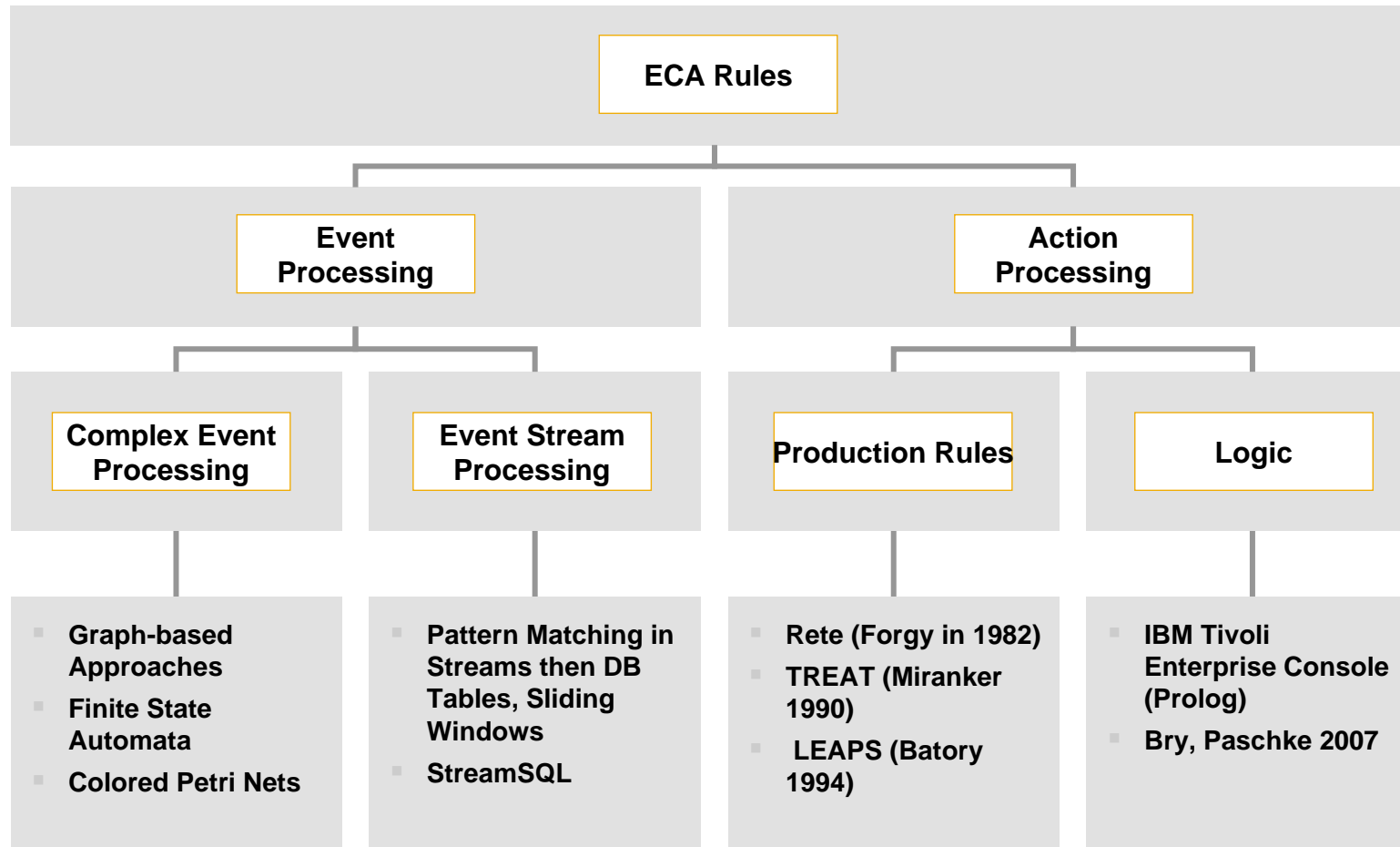
Construction of the graph from the event expressions

Example: (E1,E2);E3



The graph is a directed acyclic graph and generally does not form a tree for two reasons: nodes may have several parents, when their represented expression is part of more than one complex events, and secondly there is no single root node, when there is no overarching, single most complex event.

# Overview of the State of the Art in Event and Action Processing



# Agenda



1. Introduction
2. Survey of Event-triggered Reactivity
- 3. Requirements**
4. Future Work

Efficient combination of complex event processing with action processing

Comprehensive framework capable to deal with

- Semantics of events and actions
- Termination of rule processing
- Rule ordering

Context and Situation

- Event + Condition + Context = Situation

Reasoning over all reactivity rule constituents

Holistic approach: Event-driven Reactivity

Unique handling of the different constituents of an event-driven architecture

- events, actions, conditions, contexts and situations

Realization of next generation efficient and manageable event-driven (reactive) applications

Decrease the complexity of setting-up/evolving event-driven applications, that nowadays requires lots of manual work, especially in defining what an event is

Increase the benefits (added value) of such applications, which are currently constrained on the complex monitoring of events

Open new possibilities to apply them in highly dynamic and distributed environments

Efficient modeling of the sense-and-respond (reactive) nature of a system, especially its contextualization

Comprehensive management of the reactivity life cycle of a system, including automatic discovery of relevant situations, efficient detection of events reasoning about actions

Efficient implementation of the reactivity life cycle management

In fact, we argue that the ECA (event-condition-action, such as it is) model is too simple presentation of the (intelligent) event processing nature

Efficient context detection process is inevitable for the efficient event processing and is totally neglected in the literature

Unified mechanism for formal representation of all phases in the reaction cycle is needed for efficient and complex event processing

Usage of a richer conceptual model for describing reactions on events

Context as a first class citizen in the event processing is currently completely missing in the literature for event processing

Context-based event processing is the next "big thing"

- Shaping of the future of the computing
- Context-Driven Architecture (CoDA) is the most promising paradigm that will extend SOA

New possibilities for event triggered reactivity by reasoning about situations and context





Opens new possibilities for event triggered reactivity

Situations as formal logic models; some very interesting reasoning services can support the whole event processing

The system can check formally the consistency of the system and backtrack if a conflict (meaning inconsistency in the system) is to appear.

Another service would be the synchronization of situations if we consider that two or more reactions will run in parallel, which is a quite natural assumption in the rich-event systems.

# Agenda



1. Introduction
2. Survey of Event-triggered Reactivity
3. Requirements
4. **Future Work**

## Development of a new conceptual model and architecture of event-triggered reactivity (EtR)

- Introducing novel concepts (situation and context)
- Its formal, logic-based representation

## Development of a model for managing the whole life cycle of EtR, including

- Language for modeling EtR concepts (e.g. situations, context)
- User-friendly editor based on pattern modeling metaphor
- Methods for ensuring the consistency of such a rule base and its interoperability with other reactive systems
- New methods and tools for the automatic discovery of complex event and situation patterns from stream data by taking into account their evolution as well
- New algorithms for scalable ECA reasoning, based on the selected logic and its implementation in a new reasoning engine that will serve as the event-, condition- and action-handler in a reactive system.
- Realize, test and refine an integrated software framework for the management of EtRs life cycle, containing elements of the distributed event processing, that can be easily deployed in the selected legacy landscape
- Development of use cases, their implementation, testing and evaluation in real-world pilot studies in order to validate proposed model and framework.

Thank you!

# Definition and halftone values of colors



RGB 4/53/123	RGB 240/171/0	RGB 204/204/204	RGB 153/153/153	RGB 102/102/102	<b>Primary colors</b> 100%
--------------	---------------	-----------------	-----------------	-----------------	-------------------------------

RGB 68/105/125	RGB 21/101/112	RGB 85/118/48	RGB 119/74/57	RGB 100/68/89	<b>Secondary colors</b> 100%
RGB 96/127/143	RGB 98/146/147	RGB 110/138/79	RGB 140/101/87	RGB 123/96/114	85%
RGB 125/150/164	RGB 127/166/167	RGB 136/160/111	RGB 161/129/118	RGB 147/125/139	70%
RGB 152/173/183	RGB 154/185/185	RGB 162/180/141	RGB 181/156/147	RGB 170/152/164	55%
RGB 180/195/203	RGB 181/204/204	RGB 187/200/172	RGB 201/183/176	RGB 193/180/189	40%

100%	RGB 73/108/96	RGB 129/110/44	RGB 132/76/84	
85%	RGB 101/129/120	RGB 148/132/75	RGB 150/103/110	
70%	RGB 129/152/144	RGB 167/154/108	RGB 169/130/136	
55%	RGB 156/174/168	RGB 186/176/139	RGB 188/157/162	
40%	RGB 183/196/191	RGB 205/197/171	RGB 206/183/187	RGB 158/48/57 <b>Tertiary color</b>

# Grid



<b>SAP RESEARCH</b>					



No part of this publication may be reproduced or transmitted in any form or for any purpose without the express permission of SAP AG. The information contained herein may be changed without prior notice.

Some software products marketed by SAP AG and its distributors contain proprietary software components of other software vendors.

SAP, R/3, mySAP, mySAP.com, xApps, xApp, SAP NetWeaver, Duet, Business ByDesign, ByDesign, PartnerEdge and other SAP products and services mentioned herein as well as their respective logos are trademarks or registered trademarks of SAP AG in Germany and in several other countries all over the world. All other product and service names mentioned and associated logos displayed are the trademarks of their respective companies. Data contained in this document serves informational purposes only. National product specifications may vary.

The information in this document is proprietary to SAP. This document is a preliminary version and not subject to your license agreement or any other agreement with SAP. This document contains only intended strategies, developments, and functionalities of the SAP® product and is not intended to be binding upon SAP to any particular course of business, product strategy, and/or development. SAP assumes no responsibility for errors or omissions in this document. SAP does not warrant the accuracy or completeness of the information, text, graphics, links, or other items contained within this material. This document is provided without a warranty of any kind, either express or implied, including but not limited to the implied warranties of merchantability, fitness for a particular purpose, or non-infringement.

SAP shall have no liability for damages of any kind including without limitation direct, special, indirect, or consequential damages that may result from the use of these materials. This limitation shall not apply in cases of intent or gross negligence.

The statutory liability for personal injury and defective products is not affected. SAP has no control over the information that you may access through the use of hot links contained in these materials and does not endorse your use of third-party Web pages nor provide any warranty whatsoever relating to third-party Web pages

Weitergabe und Vervielfältigung dieser Publikation oder von Teilen daraus sind, zu welchem Zweck und in welcher Form auch immer, ohne die ausdrückliche schriftliche Genehmigung durch SAP AG nicht gestattet. In dieser Publikation enthaltene Informationen können ohne vorherige Ankündigung geändert werden.

Einige von der SAP AG und deren Vertriebspartnern vertriebene Softwareprodukte können Softwarekomponenten umfassen, die Eigentum anderer Softwarehersteller sind.

SAP, R/3, mySAP, mySAP.com, xApps, xApp, SAP NetWeaver, Duet, Business ByDesign, ByDesign, PartnerEdge und andere in diesem Dokument erwähnte SAP-Produkte und Services sowie die dazugehörigen Logos sind Marken oder eingetragene Marken der SAP AG in Deutschland und in mehreren anderen Ländern weltweit. Alle anderen in diesem Dokument erwähnten Namen von Produkten und Services sowie die damit verbundenen Firmenlogos sind Marken der jeweiligen Unternehmen. Die Angaben im Text sind unverbindlich und dienen lediglich zu Informationszwecken. Produkte können länderspezifische Unterschiede aufweisen.

Die in diesem Dokument enthaltenen Informationen sind Eigentum von SAP. Dieses Dokument ist eine Vorabversion und unterliegt nicht Ihrer Lizenzvereinbarung oder einer anderen Vereinbarung mit SAP. Dieses Dokument enthält nur vorgesehene Strategien, Entwicklungen und Funktionen des SAP®-Produkts und ist für SAP nicht bindend, einen bestimmten Geschäftsweg, eine Produktstrategie bzw. -entwicklung einzuschlagen. SAP übernimmt keine Verantwortung für Fehler oder Auslassungen in diesen Materialien. SAP garantiert nicht die Richtigkeit oder Vollständigkeit der Informationen, Texte, Grafiken, Links oder anderer in diesen Materialien enthaltenen Elemente. Diese Publikation wird ohne jegliche Gewähr, weder ausdrücklich noch stillschweigend, bereitgestellt. Dies gilt u. a., aber nicht ausschließlich, hinsichtlich der Gewährleistung der Marktgängigkeit und der Eignung für einen bestimmten Zweck sowie für die Gewährleistung der Nichtverletzung geltenden Rechts.

SAP übernimmt keine Haftung für Schäden jeglicher Art, einschließlich und ohne Einschränkung für direkte, spezielle, indirekte oder Folgeschäden im Zusammenhang mit der Verwendung dieser Unterlagen. Diese Einschränkung gilt nicht bei Vorsatz oder grober Fahrlässigkeit.

Die gesetzliche Haftung bei Personenschäden oder die Produkthaftung bleibt unberührt. Die Informationen, auf die Sie möglicherweise über die in diesem Material enthaltenen Hotlinks zugreifen, unterliegen nicht dem Einfluss von SAP, und SAP unterstützt nicht die Nutzung von Internetseiten Dritter durch Sie und gibt keinerlei Gewährleistungen oder Zusagen über Internetseiten Dritter ab.

Alle Rechte vorbehalten.