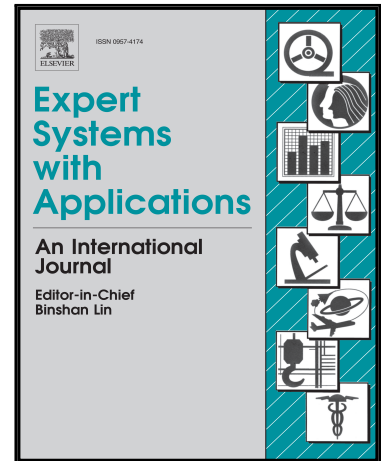


## Accepted Manuscript

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PII: S0957-4174(17)30791-1  
DOI: [10.1016/j.eswa.2017.11.033](https://doi.org/10.1016/j.eswa.2017.11.033)  
Reference: ESWA 11676



To appear in: *Expert Systems With Applications*

Received date: 5 June 2017  
Revised date: 14 November 2017  
Accepted date: 15 November 2017

Please cite this article as: Alvine Boaye Belle , Timothy C. Lethbridge , Miguel Garzón , Opeyemi O. Adesina , Design and implementation of distributed expert systems: on a control strategy to manage the execution flow of rule activation, *Expert Systems With Applications* (2017), doi: [10.1016/j.eswa.2017.11.033](https://doi.org/10.1016/j.eswa.2017.11.033)

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# Design and implementation of distributed expert systems: on a control strategy to manage the execution flow of rule activation

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## ARTICLE INFO

### Article history:

Received 00 December 00

Received in revised form 00 January 00

Accepted 00 February 00

### Keywords:

Rule-based expert systems

Meta-rules

Control strategy

Selective inference

Assurance case

Feature identification

## ABSTRACT

—There is a rich body of work dedicated to expert systems. However, none of them focus on control strategies suitable for distributed environments. We describe a novel approach to design distributed expert systems that is able to control rule activation; it involves control strategies supporting selective inferencing with rules that propagate concurrently and incorporates a set of meta-rules that operate on a blackboard and that are expressed as an assurance case. It is implemented on top of ERESYE, a tool for the realization of expert systems that is written in Erlang. We describe an implementation of the approach in an industrial setting, using an example focusing on the feature identification problem, whose resolution is an important task for source code maintenance and evolution.

## 1. Introduction

Expert system (ES) technology is mature, pervasive and successful (Marcus, 2013; Liao, 2005; Quan and Jingsong, 2008). However, there are still many opportunities for improvement. The enhancements we report in this paper are the development of control strategies to enable expert systems to work in a distributed, multi-processor environment. Control strategies rely on heuristics to identify the applicable knowledge sources to activate (Buschmann et al., 1996). We demonstrate our work in the context of the ERESYE (ERlang Expert SYstem Engine) rule engine implemented in Erlang – a programming language being used in the industrial sector.

Di Stefano et al. (2005) pointed out that common languages such as C++ or Java lack native constructs required to adequately represent rules and knowledge, so require an external tool to support these. Erlang, however, has a declarative nature, and so is a more natural fit for ES needs. It is widely used for programming concurrent, scalable, fault-tolerant, distributed and high-performance systems (Di Stefano et al., 2005; Armstrong, 2007). Erlang's syntax and semantics also make it a potentially better candidate for rule-based expert systems than Prolog and

LISP (Di Stefano et al., 2005; Armstrong, 2007). ERESYE is a native implementation of a rule engine in Erlang, specifically designed to create, manage and run inference engines (Di Stefano et al., 2005). Each engine has a knowledge base and a rule base.

The blackboard architectural pattern allows designing an expert system using various components including a control component implementing control strategies. In ERESYE, control is handled at the rule level by relying on a modified version of the RETE algorithm (Forgy, 1982), which identifies the rule to activate based on a change in the knowledge base (Di Stefano et al., 2005). The low-level of granularity is a well-known scalability issue in pure rule-based expert systems. Certain control strategies in the context of Blackboard Architecture have involved more coarse-grained Knowledge Sources (KS) as sets of rules that are more manageable and scalable parts of a solution (e.g., (Andress and Kak, 1988)). ERESYE needs an extra layer to perform activations specifically at the KS level. The key challenge addressed in this paper is to extend ERESYE to do this.

An important motivation for our work is to enable expert systems to have a control strategy that can work in a high-performance concurrent environment. Applications of concurrent expert systems would include.

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