



An approach for the evolutionary discovery of software architectures

Aurora Ramírez, José Raúl Romero, Sebastián Ventura

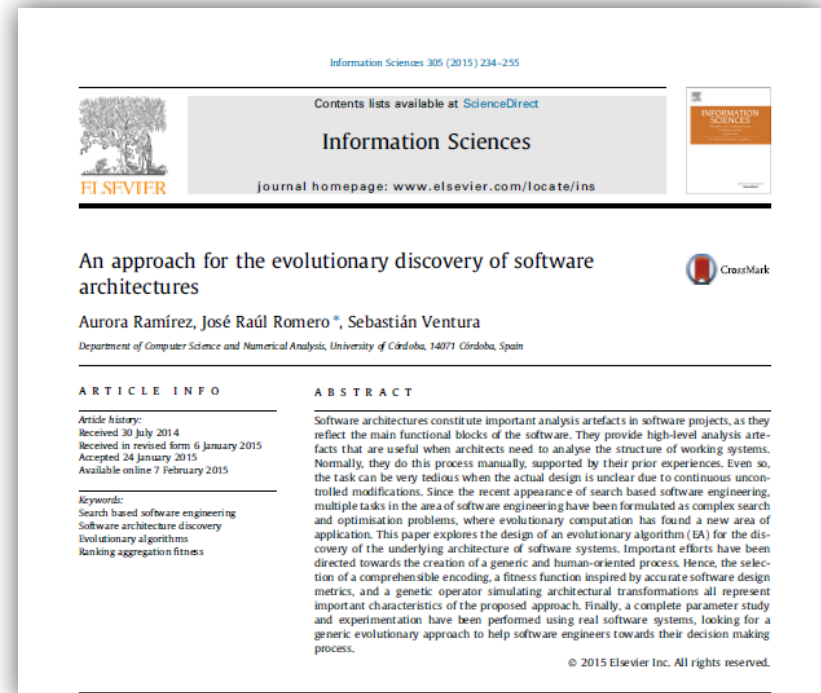
Dept. Computer Science and Numerical Analysis. University of Córdoba.

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A. Ramírez, J.R. Romero, S. Ventura.
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Sciences*, vol. 305, pp. 324-255. 2015.



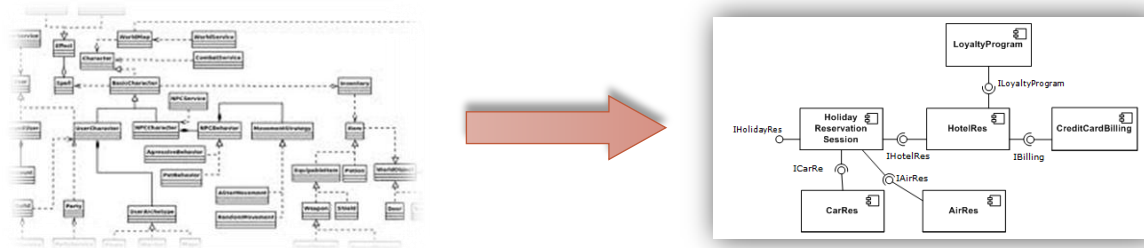
Introduction

- Software architects face complex design decisions
 - Software structure, platforms, styles...
 - Functional and **non-functional requirements**
 - Few information at this stage of the development
- **Search Based Software Engineering**
 - Support in decision making
 - Exploration of **design alternatives**



The search problem

- We want to automatically identify the underlying architecture from an analysis model (represented as a class diagram)



- It can be a too demanding, complex and time-consuming task
- **Evolutionary algorithms** may serve to (semi-)automate the process of finding optimal software architectures
- A extremely high combinatorial problem

The search problem

Research questions

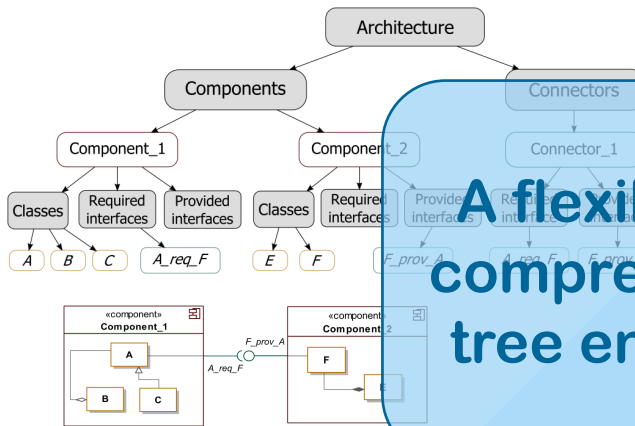
RQ1: Can single-objective evolutionary algorithms help the software engineer to identify an initial candidate architecture of a system at a high level of abstraction?

RQ2: How does the configuration of the algorithm influence both the evolutionary performance and the quality of the returned solution?



Evolutionary approach

Key elements



A flexible and comprehensive tree encoding

$$fitness(ind) = \begin{cases} r(ICD_{ind}) + r(ERP_{ind}) + r(GCR_{ind}) & \text{if } ind \text{ is valid} \\ \frac{\#classes_{total} - \#classes_i}{\#classes_{total}} \cdot \frac{CI_i^{in}}{CI_i^{in} + CI_i^{out}} & \text{if } ind \text{ is invalid} \end{cases}$$

A fitness function based on three design metrics

$$ICD_i = \frac{\#classes_{total} - \#classes_i}{\#classes_{total}} \cdot \frac{CI_i^{in}}{CI_i^{in} + CI_i^{out}}$$

$$ICD = \frac{1}{n} \cdot \sum_{i=1}^n ICD_i$$

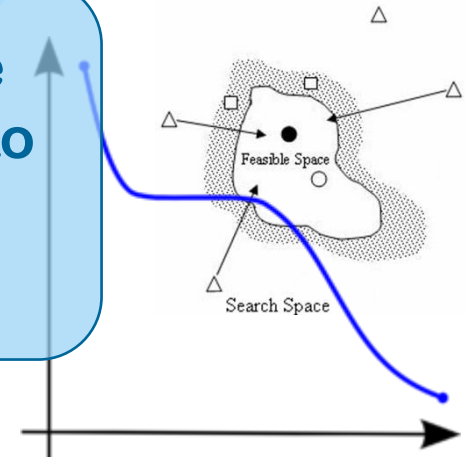
$$ERP = \sum_{i=1}^n \sum_{j=1}^n [w_{as} \cdot n_{as_{ij}} + w_{ag} \cdot n_{ag_{ij}} + w_{co} \cdot n_{co_{ij}} + w_{ge} \cdot n_{ge_{ij}}]$$

$$GCR = \frac{\#cgroups}{\#components}$$

RQ1

A mutation operator able to perform five architectural transformations

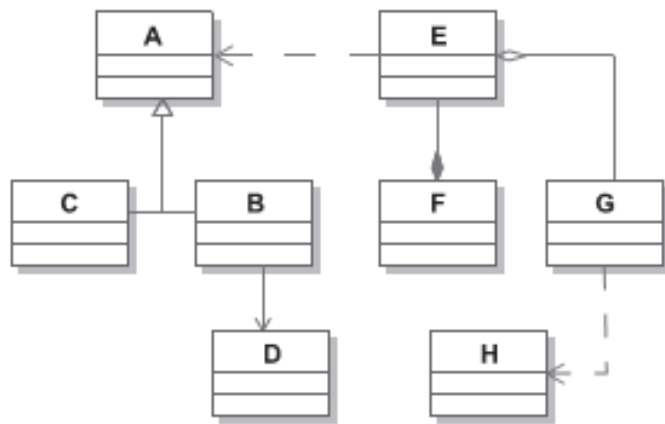
An adaptive mechanism to deal with constraints



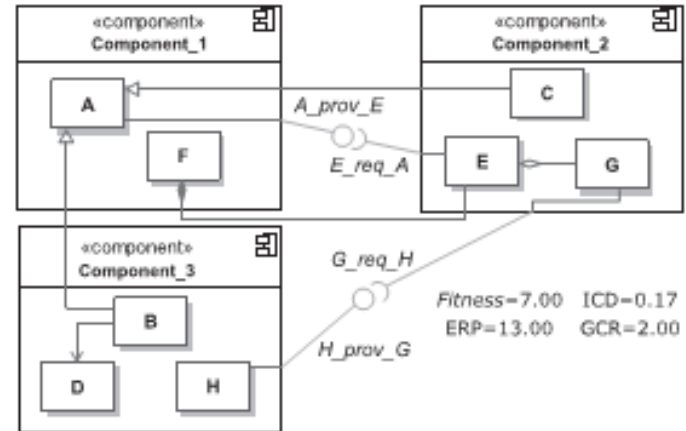
Evolutionary approach

Illustrative example

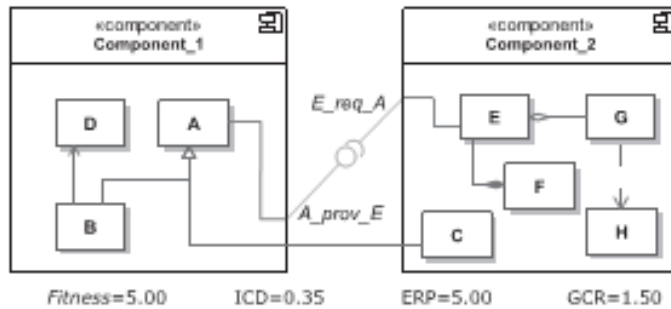
RQ1



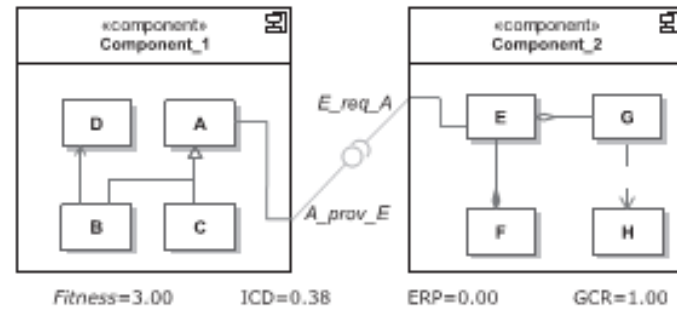
(a)



(b)



(c)



(d)

Experimental study

RQ2

Parameter study

Selection	deterministic / tournament / roulette
Replacement	best / competition / elitism / elitism (10%) / binary tournament
Mutation	[0.1,0.6] -- $P_{\text{add}} = \mathbf{0.2}$ $P_{\text{remove}} = P_{\text{merge}} = \mathbf{0.1}$ $P_{\text{split}} = P_{\text{move}} = \mathbf{0.3}$
Population Size	50, 100, 150 , 200
Stopping criterion	convergence every 1200 evaluations: 20000-24000

Experimental results

- Optimal or near optimal values for **GCR**
- ICD and ERP require to **strike a balance**
- Without assuming any structure, it can **identify related functional blocks**
- Importance of the **number and types of relationships** among classes

Conclusions

- Evolutionary Computation as **an exploratory mechanism** to decision support
 - Identify blocks of **related functionality**
 - **Without** assuming any structure
- The search approach **is close to the architect**
 - **Flexible and comprehensible** representation
 - Architectural transformations with **heuristic information**
 - Fitness function based on **design metrics**

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Thanks!



UNIVERSIDAD DE CORDOBA

Aurora Ramírez

Email. aramirez@uco.es

Web. <http://www.uco.es/users/aramirez/en>

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