



Evolutionary Computation Technical Committee
Workgroup on Future Directions in Evolutionary Computation

A Practical Model for Evolutionary Computation Market Introduction

White Paper
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Paul Tabor ¹ and Ali M S Zalzal ²

¹ Vantage Media, LLC, 2101 Rosecrans Avenue, Suite 2000, El Segundo, CA
90245

² Hikma Group Ltd, PO Box 42423, Dubai, UAE



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PROLOGUE

The EDCTC Workgroup on Future Directions in Evolutionary Computation has been running a workshop, associated with the Congress on Evolutionary Computation, and aiming to *assist in defining future development of the theory and application of Evolutionary Computation*. There have been a number of presentations, debates and discussions from leaders in the EC field. These culminated in defining four themes along which a better understanding of the EC field may be pursued. The four themes are listed Table (1).

In presenting this white paper, ECTC seeks to provide a generic and practical approach to pursue and realize the ideas gathered by this international effort. This one approach will be utilized to seek an investigation into the various items of the four themes, hence contributing to the definition of future directions of evolutionary computation.

No	Theme Title	Items
1	Working with other fields	<ul style="list-style-type: none">• Terminologies• Hybridization• Domain experts + EC experts
2	Getting industry on-board	<ul style="list-style-type: none">• Defining their problems (which they do not know about)• Having convincing applications• Fast answers to meaningful problems
3	Education issues	<ul style="list-style-type: none">• Proper background: lack of mathematics for biology/computer science students• Career development and convincing research• Interdisciplinary area for students and researchers
4	Is EC the answer?	<ul style="list-style-type: none">• Scalability and time complexity• Balance of applications & theory• Industry input in EC meetings



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I. INTRODUCTION

Evolutionary computation (EC) has the capability to substantially improve a wide array of process, analytics, informatics, and manufacturing applications. Many EC publications and solutions have been presented purely within the scope of research and theoretical applications. The gap between theoretical solutions and solving current real-world problems with EC must be narrowed for EC to gain widespread industry acceptance. Traditionally, academic partnerships have been viewed as pure R&D, or at least, a long-term venture. EC needs to be marketed to industry as a short-term, practical solution when engaging with academia.

EC solutions are usually implemented within in the scope of a software application or solution. Whether it be financial applications, bio-informatics, or other type of process, EC has basic requirements of taking inputs, data, etc. and generating appropriate outputs.

In many high-technology and complex manufacturing operations, there can be many types of domain experts. For instance, the semiconductor industry is comprised of many vertical domains and disciplines to support operations at several levels, such as: physics, chemistry, electrical engineering, software development, statistical analysis, mechanical engineering. To effectively compete in these sectors, it is critical that companies employ applicable domain expertise. Likewise, any EC solution targeted for vertical applications must be supported from associated industry experts. This creates somewhat of a “chicken versus egg” scenario where industry experts are not aware of EC as a potential improvement within their domain, and EC experts (vendors, academia, etc.) don’t know whom to talk to and which questions to ask when searching for problems to solve.

Ultimately, for EC to gain ground as a de-facto solution addressing current real-world problems, the push must come from industry to adopt EC techniques, employ EC experts, and proactively engage with academia. Competitive advantages gained by EC integration can drive awareness and acceptance of EC solutions through many markets and domains. Unfortunately, this is a significant challenge as companies are typically busy with support and resource



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requirements, and are unaware of the potential of EC in their environment.

So how does EC reach this state of proliferation nirvana? Efforts have already begun, and numerous academic programs and industry adoptions have already been established.

Although efforts have initiated which are improving the future of EC, there is so much more opportunity for EC adaptation in many industry applications, and overall industry EC acceptance is still in its infancy. The purpose of this paper is to outline the EC Market Introduction Template discussed in the FDEC Workshop taking place during the 2005 IEEE Congress on Evolutionary Computation.

II. CHALLENGES AND ROLES

Before diving into the model details, it is prudent that we examine the challenges and roles associated with industry and academia engagements.

II.1.Challenges

Most of the challenges introduced into a company-academic engagement come from the company side, particularly in the area of project funding. A common planning consideration is whether or not there is sufficient return on investment (ROI) to justify project expenditures. There are four main challenges pertaining to project economics: market, timing, resources, and intellectual property rights.

II.1.A. Market challenges

Whether an internal process, commercial product, or other solution, there must be a market or end user who defines the project outcome and provides economic justification. Evaluation of market potential is an important first step in EC introduction planning as several marketing dynamics significantly influence project priorities and milestones. This process is intrinsically dependent on business / domain knowledge and is driven by the company with little or no input required from academia. However, when partnering with



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business, academia can influence this process by emphasizing the points that pertain to EC-enabled technology. For instance:

- What is the purpose for introducing EC into the technology, process, or product (e.g. competitive advantage, process improvement, cost savings, etc.)?
- Is there a clear problem statement?
- Who is the end-user? Who is the buyer? What is the level of domain expertise for each?
- How long is the sales cycle? What impact might EC features have on the sales cycle?
- Are there competitive solutions? What competitive techniques are used?

These and other questions will be addressed later in the *EC Market Introduction Template* section.

II.1.B. Timing challenges

There are two timing aspects that attribute to overall risk regarding the introduction of EC tools: product/process lifecycle, and time to market (TTM).

First, when considering existing solutions (i.e. retrofitting EC techniques to an existing process), the timing of EC introduction relative to the overall solution lifecycle can determine whether or not the project should commence at all. For instance, consider a scenario in which EC techniques introduced to a data analysis process would significantly enhance the performance of that analysis process. However, if the analysis process is dependent on a proprietary data format that is being replaced by a new format that requires a new analysis process, then there is a compelling reason **not** to commence with EC process upgrades – regardless of the potential gains or improvements in the process itself. This is because even if EC upgrades are performed, the process would soon become obsolete and thus any ROI would be lost.

The second timing issue is associated with TTM, or Time to Market. TTM is a measure of how quickly a product or process can be introduced to its associated market or end user. Typically, a shorter TTM equates to greater opportunity, increased revenue, or cost savings. When evaluating EC as part of a solution, one must



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consider the research, design, and development time. In the context of a new product or process, a new approach overhead can be significant as other parts of the project may be evolving thus creating a moving target for EC feature integration. The partnership structure proposed in the *EC Market Introduction Template* section addresses these issues through structured planning, roles, and objectives. Although outside the scope of this discussion, other methodologies can help accelerate EC integration independently of any project constraints, such as using a *Design for EC* concept.

Design for EC is essentially a product design strategy that makes liberal use of well-defined design patterns and certain software development methodologies. By embracing a Design for EC strategy during initial stages of product development, an application will be much more adaptable to EC features at any stage of development. Essentially, Design for EC is a concept that enables a product to be both agnostic and extensible to EC integration. This provides greater flexibility in terms of resource allocation, milestones, and overall planning. A side-effect of utilizing Design for EC concepts is that solutions are modular, easier to maintain, and extensible to other techniques and technologies.

II.1.C. Resource challenges

Economic fluctuations, globalization, and shareholder obligations are but a few factors that contribute to resource scrutiny with any project planning effort. Furthermore, introduction of new techniques, such as EC, can be difficult to quantify from a planning perspective. Project managers are challenged with adopting / understanding new technology, while simultaneously meeting project milestones and balancing corporate objectives. To have a successful marriage between industry and academia, a clear understanding of resource requirements must be defined up front. The *EC Market Introduction Template* section addresses this issue by outlining logistical resource quantification steps that can help identify potential resource pitfalls and help with overall project planning.



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II.1.D. Intellectual property (IP) challenges

Who owns what? Ideally, universities desire some sort of revenue generating licensing or royalty arrangement with industry. In fact, many universities have legal departments and private arms that deal with this issue exclusively. Industry, on the other hand, wants to “own” everything as they are providing the domain expertise, market opportunity, and typically bear the brunt of the cost to develop / market / sell / deploy. As outlined in the EC Market Introduction Model¹, there is an opportunity for academia to seize a greater ownership interest in intellectual property rights via the Delayed ROI Model. In any case, as complex as this issue may become once engaging in a relationship, it is usually governed by a simple rule, the party contributing the most gets more.

II.2. Roles

To implement a successful EC marriage between academia and industry, each party must play a role to entertain the courtship process.

II.2.A. Role of Academia

Concerning new technology introduction, academia must lead the work to demonstrate which techniques and tools are ready for industrial adaptation. As a strong portion of academic activity is research-centric, and as new techniques are proven and discovered which have applications in existing or emerging industrial fields, academia must initiate efforts to promote these types of techniques. While many conferences and such address this effort through various white papers and workshop presentations, additional steps must be taken to further the awareness of EC solutions. For example, in exchange for diminished intellectual property rights, a university may negotiate advertising and marketing rights with private industry to promote the efforts and credibility of the university within the private sector.

II.2.B. Role of Industry

Quite simply, industry must be the driving force for widespread EC acceptance through recruitment of new graduates, dissemination of marketing collateral (such as white papers, studies), and



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proliferation of EC-enabled solutions. However, industry may be generally oblivious to EC benefits thus unaware and stagnant to EC implementation initiatives. One way to improve this scenario is by facilitating relations between academia and industry in a way that is familiar to industry. Such is a primary goal of the *EC Market Implementation Template*, to provide guidelines that enable industry and academia to quickly identify:

- opportunities
- benefits and advantages
- resource impact
- timelines, milestones, and deliverables
- cost

III. Evolutionary Computation (EC) Market Implementation Template

Considering the vast differences between various industries worldwide, it is impossible to have a single model or set of rules that effectively govern all scenarios. Therefore, it is important that this template be viewed as flexible guidelines that should be adapted for each individual situation and industry. The template is designed so that each party (industry and academia) can focus on what they bring to the table for their part, and allow the other to “fill in the blanks” per se... ultimately forming the basis for a well-understood, commercially viable development or research project.

Academia

1. IMPLEMENT FLEXIBLE DEGREE PROGRAMS
 - a. Multi-student degree programs
 - b. Multi-goal degree programs
 - c. Cross-functional degree programs
 - d. Non-published thesis degree programs
2. INITIATE CONTACT
 - a. Market degree programs to industry as:
 - i. Designed to accommodate large projects
 - ii. Designed to accommodate commercial marketing objectives
 - iii. Designed to protect industry trade secrets



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- b. Inform and educate potential industry partners about EC from an ROI standpoint:
 - i. Competitive advantages
 - ii. Leading edge techniques
- 3. CONSIDER DELAYED ROI SCENARIOS
 - a. If small companies or startups are potential candidates, then consider sponsoring the student(s) in exchange for shares and/or increased royalties
- 4. MARKETING COLLATERAL
 - a. Contribute to marketing collateral in the form of white papers, essays, and presentations
 - b. Insist, request, or negotiate on exposure in other company marketing materials (such as "... in conjunction with the University of...").

Industry

- 1. ACADEMIA AS A PARTNER
 - a. Plan for academia as a long-term partner that can contribute at all levels within any stage of product or project development.
 - b. Multi-goal, multi-phase projects:
 - i. Consider a student(s) with a flexible degree that can accommodate more than one primary goal (multi-goal degree). This facilitates typical project planning requirements. The key is to balance project milestones with academic objectives.
 - c. Large projects with many tiers and dimensions:
 - i. Consider utilizing multiple students on the same project goal. If the project scope is vast (widespread datum, global dimensions, etc.) then a single student may be insufficient to effectively contribute. A team of students collaborating on a complex project / goal is a viable option.
- 2. DETERMINE APPROPRIATE PROJECT
 - a. Software centric
 - b. Commercial or research
 - c. Plan B
- 3. IDENTIFY AND PROVIDE DOMAIN CHAMPION



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- a. Domain expertise is a critical element when engaging with academia, particularly in the context of an evolutionary computation project. Without a domain champion, student contributors will struggle to meet milestones. A company must be committed to allocating essential domain expert(s) for the duration of the project commitment.
4. LOGISTICAL RESOURCE QUANTIFICATION
 - a. Dedicated domain expert
 - b. Evaluate project scope and milestones
 - c. Travel budget, conferences
 - d. Determine dependent tasks / objectives
 - e. Outline expected deliverables
 - f. Identify minimum deliverables
 - g. Revisit these items quarterly, revise milestones if necessary
5. SORT OUT IP OWNERSHIP / ROYALTIES
 - a. This is an issue that should be addressed with a simple rule: whomever contributes more gets more.
 - b. Advice for academia:
When working with larger companies with well defined domain expertise and deep pockets, you'll probably hardly have any claim to any IP rights for the resulting work.
 - c. Advice for startups / small companies:
If you have a good business plan and a funding roadmap, consider exchanging a significant percentage of revenue for academic support and sponsorship for the resulting product, project, etc. Although this could require a fair amount of due diligence, universities positioned to operate in this fashion have great residual revenue potential, and the company stands to reach product milestones faster and with greater initial functionality. In this model, academia is a planned, critical resource.
 - d. Advice for both:
Be deliberate, forthcoming, and clear about all expectations.
6. BALANCE TRADE SECRET PROTECTION WITH MARKETING COLLATERAL



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- a. During the development process, industry may want to remain “silent” about key product development initiatives to maintain a competitive advantage. As the goal is to partner with academia, there should be a balance between maintaining trade secrets and facilitating academic objectives of publishing viable projects for recognition and prestige.
- b. Provisional patents and segmentation of technology / technique from domain application are just two methods of dealing with this issue.

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