Organizational Design Optimization
Using Genetic Programming

Bijan KHosraviani, Raymond E. Levitt
and John R. Koza
Stanford University

GECCO 2004 Conference
June 30, 2004
Presentation Outline

- Introduction / Motivation
- Objectives / Research Questions
- Research Methodology
- Results to Date
- Conclusions
## Evolution of Organization Design

<table>
<thead>
<tr>
<th>Trial-&amp;-Error Adaptation</th>
<th>Org’n Analysis: VDT/SimVision</th>
<th>Org’n Design: VDT+Optimizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Set project objectives.</td>
<td>1. Set project objectives.</td>
<td>1. Set project objectives.</td>
</tr>
<tr>
<td>2. Propose organization.</td>
<td>2. Propose alternative organizations.</td>
<td>2. Propose initial organization as starting point for optimization.</td>
</tr>
<tr>
<td>3. Complete project using proposed organization and observe outcome.</td>
<td>3. Model alternative organizations and simulate each one to predict outcomes.</td>
<td>3. Evolve many alternative organizations; predict performance of each one; evaluate “fitness”.</td>
</tr>
<tr>
<td>4. Succeed or fail. Try to learn and adapt.</td>
<td>4. Choose solution that optimizes outcomes.</td>
<td>4. Evolve optimal organizational configuration by selective reproduction &amp; mutation of alternatives.</td>
</tr>
</tbody>
</table>
Motivation

- Project organization design is a complex, multi-dimensional, optimization problem
- Analysis tools exist for organizational design, but no known automated optimizer exists
- Finding an optimal or near-optimal solution is a challenging task even for an experienced PM
Objectives / Research Questions

Objectives

- Develop an optimizer for VDT using evolutionary computing techniques to help project managers find near-optimal designs for their project organizations
- Validate the postprocessor against both theory and practice

Research Questions

- How can GP help a highly experienced manager in designing a project organization?
- Are “optimal” solutions found by GP in-line with organization theory and management best practices?
- What are the limits of GA/GP for organization design?
Evolutionary Computing Approach to Project Design Optimization

Introduction

Objectives

Methodology

Results

Conclusions

June 30, 2004

Organizational Design Optimization
VDT Case Study: Design-Build Biotech Plant Case

Objective

- Shorten the simulation duration while maintaining acceptable quality risk

Acceptable interventions:

- Increase the skill level (from low to medium, or medium to high) for any one skill for any one actor.
- Add a total of up to 3 FTE’s in increments of not less than 0.5 FTE to any combination of actors.
- Change levels of centralization, formalization, or matrix strength
Fitness Function

A Plausible Fitness Function for this Problem =

$$SPD + TFTE \times FTEW + \sum_{i=1}^{M} (FRI_i \times FRIW_i + PRI_i \times PRIW_i + CR_i \times CRW_i)$$

Where
- $SPD =$ Simulated Project Duration
- $TFTE =$ the Total FTE added
- $FTEW =$ FTE Weight (if TFTE $>$ 3.0 $=>$ equals 1000 otherwise 1)
- $FRI(i) =$ Functional Risk Index for activity $i$
- $FRIW(i) =$ $FRI$ weight for activity $i$ (if $FRI(i) > 0.5$ $=>$ equals 1000 otherwise 1)
- $PRI(i) =$ Project Risk Index for activity $i$
- $PRIW(i) =$ $PRI$ weight for activity $i$ (if $PRI(i) > 0.5$ $=>$ equals 1000 otherwise 1)
- $CR(i) =$ Communication Risk for activity $i$
- $CRW(i) =$ $CR$ weight for activity $i$ (if $CR(i) > 0.5$ $=>$ equals 1000 otherwise 1)
- $M =$ maximum number of activities
Transforming Genetic Tree

- 1st Skill of Actor P1 is increased by one level
- 2nd skill of P1 is decreased by one level
- 3rd skill of P1 is increased by one level

Activities of P3 and P5 are swapped

- Centralization is increased by one level
- Formalization is decreased by one level
- Matrix Strength is increased by one level

FTE is increased by 0.5
Actors Skill Levels

- Total of 29 skills for 7 Actors
- Each skill can be set to 3 levels of low, medium, high
- Total Number of combinations $= 3^{29} = 6.8 \times 10^{13}$
Optimizing Actors Skill Levels

Genetic Tree Set up

- Terminal Sets = {Up, Down, Same}
- Function Sets = {P1..P7}
- Population size M = 100
- Maximum number of generations = 50
- Crossover = 90%  Mutation = 3%  Reproduction = 7%

Best Individual found after 16 generations

Was it the optimal solution?!

- No – But it was pretty close: (Both reduced schedule by 69 days)
  - Optimal solution Simulation Project End = 1/17/2001  8:29AM
  - GP near-optimal Simulation Project End = 1/17/2001 2:25PM
  - Difference:
    - Skill 4 (Geotechnical) of Project Engineer increased from medium to high
Best Individual of Generation 16

(Up P4 (Same (Same P1 P2) (Up (Up P5 (Same (Same (Up (Same P3 P1) (Up P6 (Up P4 (Up (Down P3 P2) P0)))) (Up (Down P3 P2) P0)) (Same (Up P0 (Up P0 (Down P3 P2))))) (Up (Down P5 P2) P0)))) P0))
Optimization Using Reassignment, Attention Allocation and Actors’ FTEs

**Genetic Tree Set up**
- Terminal Sets = \{Up, Down, Same, FTE, Assign, Aloc\}
- Function Sets = \{P1..P7\}
- Population size \(M = 3000\)
- Maximum number of generations = 100
- Crossover = 90%  Mutation = 3%  Reproduction = 7%

**Best Individual found after 21 generations**

**Found Best Solution Ever!**
- Student/Manager Simulated End date=Dec 7, 2000
- GP Solution Simulated End date = Dec 5, 2000

GP Solution:
- Matched FTE additions additions in same location & same quantity
- Found additional Reassignment + changes in Attention Allocation

![Graph showing 2.6% improvement](image)
Comparing Assignments and FTEs Increments (GP vs. Student Solution)
Project Duration Improvement
Before and After Intervention

Before

After
Quality Risk Improvement
Before and After Intervention

Project Communications Risk

Before

After

June 30, 2004
Organizational Design Optimization
Fitness Improvement thru Generations

![Graph showing fitness improvement through generations. The graph illustrates the decline in fitness values (Best Fitness and Mean Fitness) as generation numbers increase from 1 to 31. The y-axis represents fitness values ranging from 27000 to 62000, while the x-axis shows generation numbers.]
Conclusion & Future Research

## Conclusion

- GP post processor for VDT beats the best human trial-and-error performance of > 40 graduate student & practitioner teams over the past 8 years

## Future Research

- Develop new “Micro-Contingency Organization Theories Using GP Optimizer
- Integrate GP Optimizer into VDT
- Add additional variables to optimize as VDT is extended to model impacts of cultural differences in global projects
Questions?