Organizational Design Optimization Using Genetic Programming

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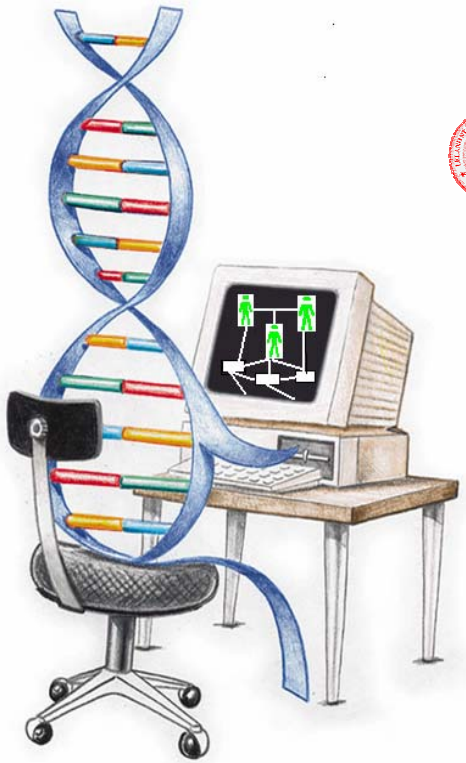

GECCO 2004 Conference

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Presentation Outline

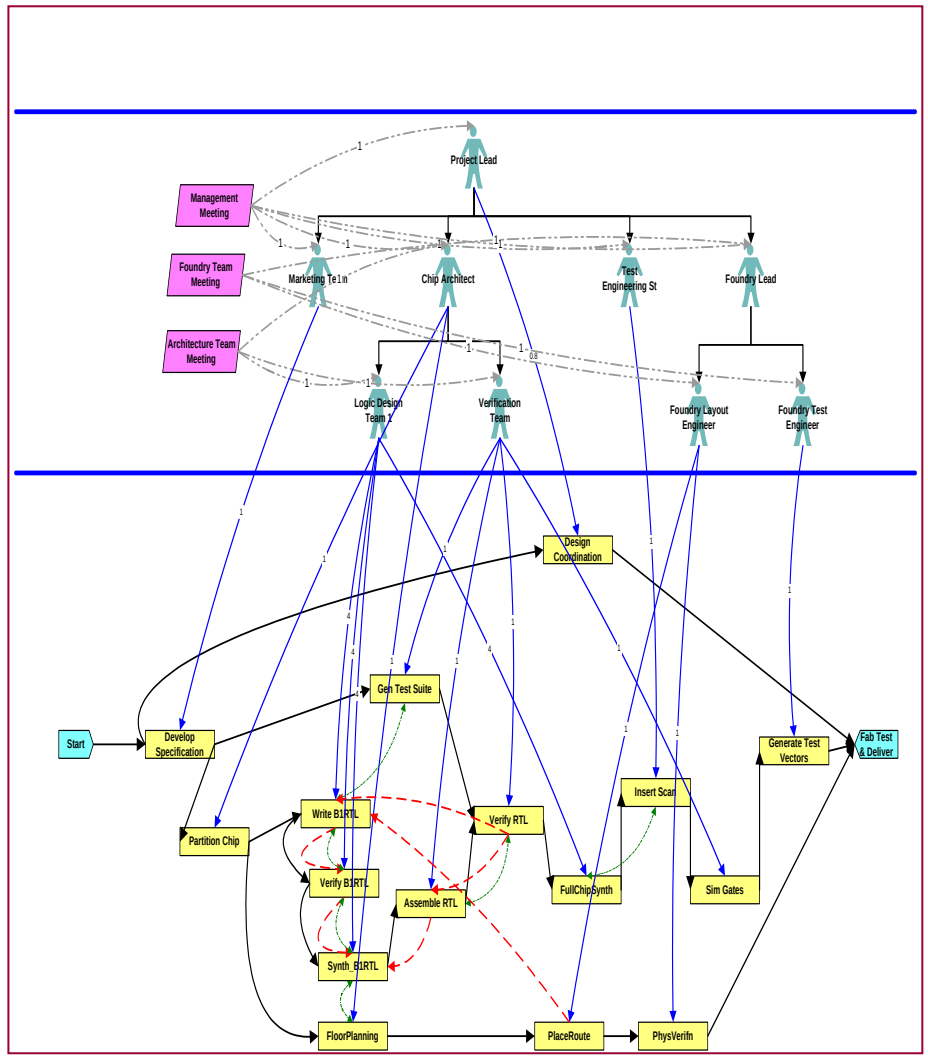
- Introduction / Motivation
- Objectives / Research Questions
- Research Methodology
- Results to Date
- Conclusions

Evolution of Organization Design

Trial-&-Error Adaptation	*Org'n Analysis: VDT/SimVision*	*Org'n Design: VDT+Optimizer*
1. Set project objectives.	1. Set project objectives.	1. Set project objectives.
2. Propose organization.	2. Propose alternative organizations.	2. Propose initial organization as starting point for optimization.
3. Complete project using proposed organization and observe outcome.	3. Model alternative organizations and simulate each one to predict outcomes.	3. Evolve many alternative organizations; predict performance of each one; evaluate "fitness".
4. Succeed or fail. Try to learn and adapt.	4. Choose solution that optimizes outcomes.	4. Evolve optimal organi-zational configuration by selective reproduction & mutation of alternatives.

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

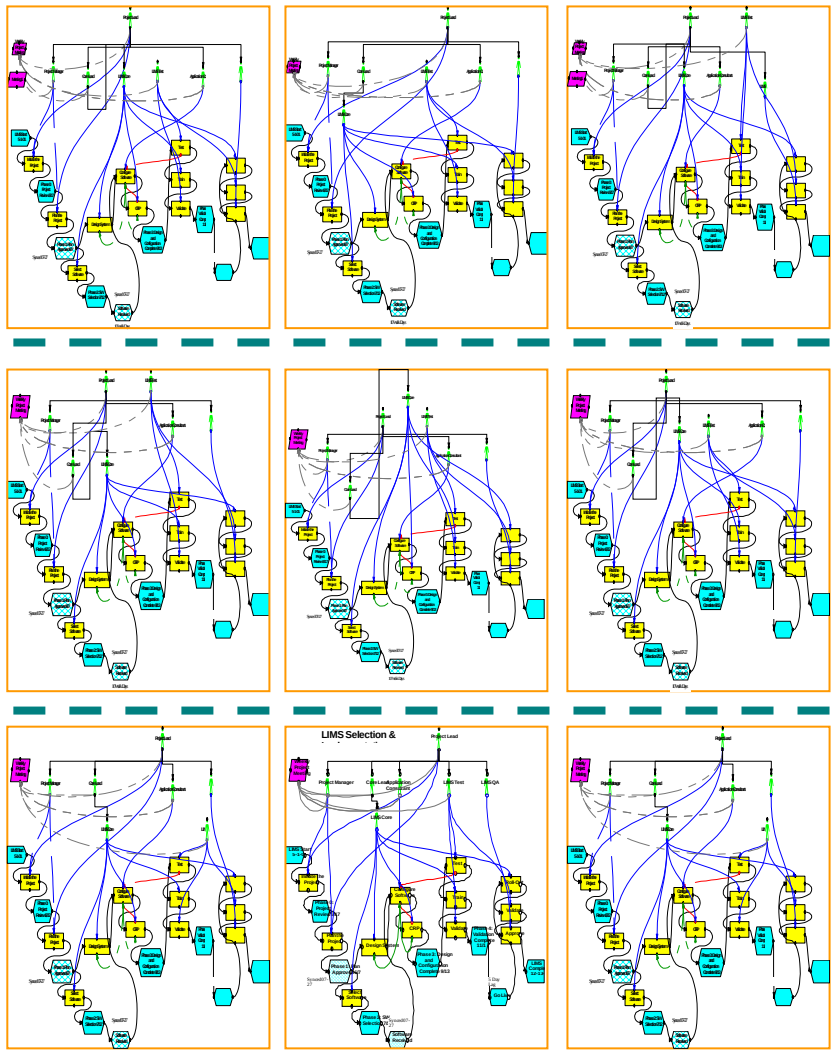
- How can GP help a highly experienced manager in designing a project organization?
- Are “optimal” solutions found by GP in-line with organization theory and management best practices?
- What are the limits of GA/GP for organization design?

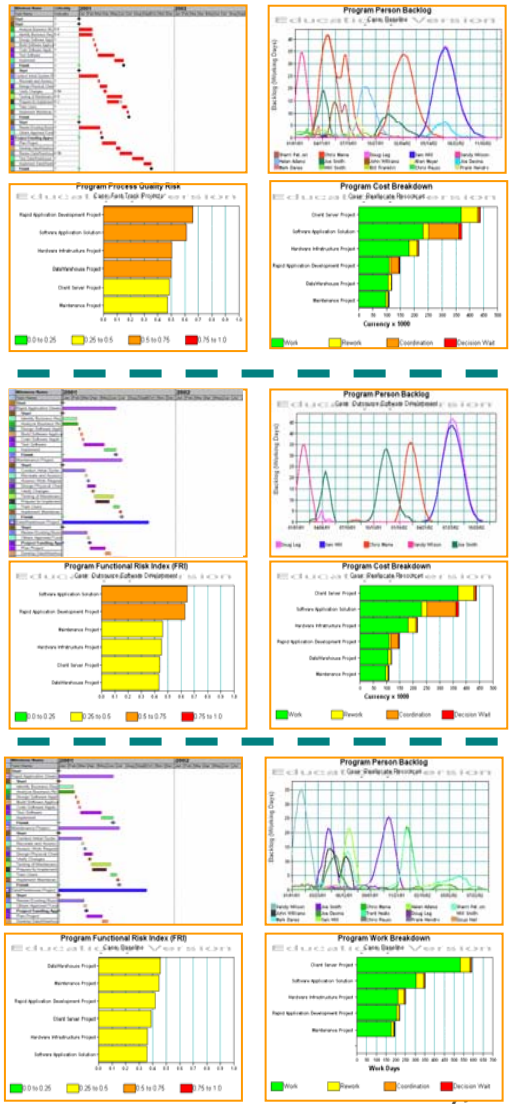
Evolutionary Computing Approach to Project Design Optimization

Gen. 0

Gen. 1

Gen. 2





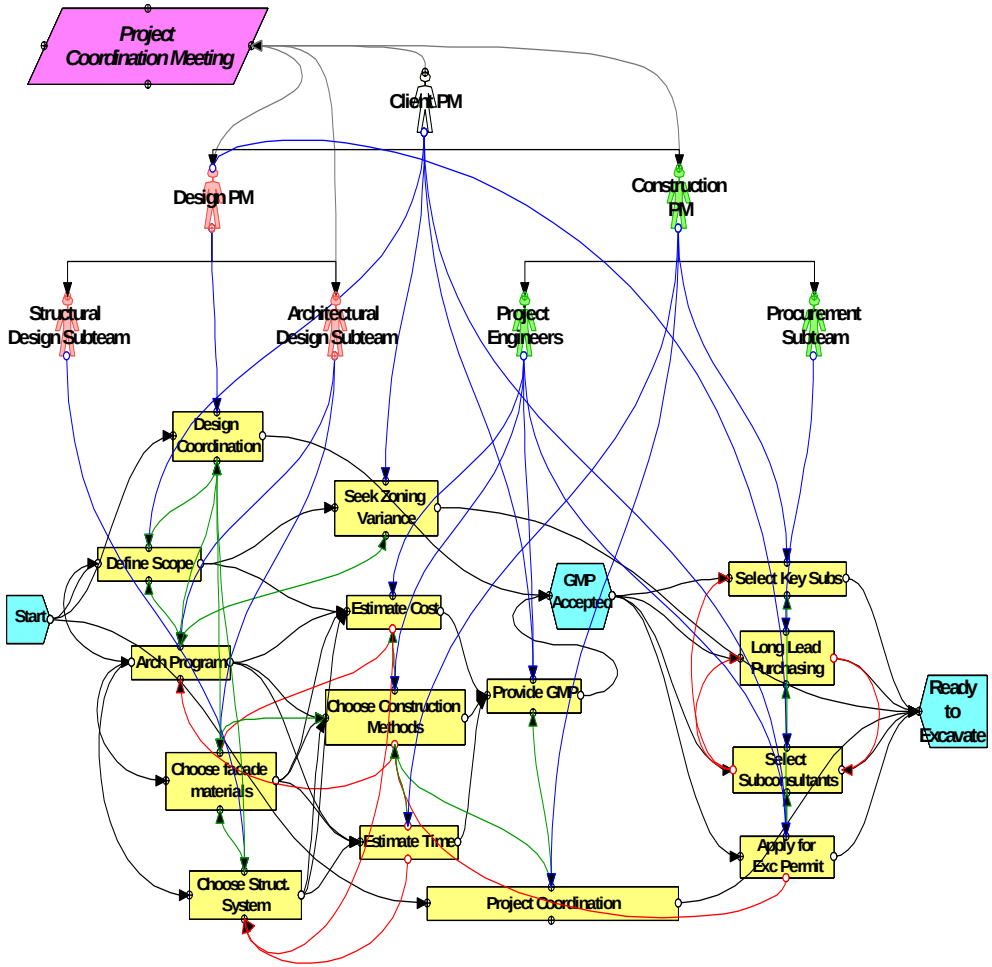
VDT Case Study: Design-Build Biotech Plant Case

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

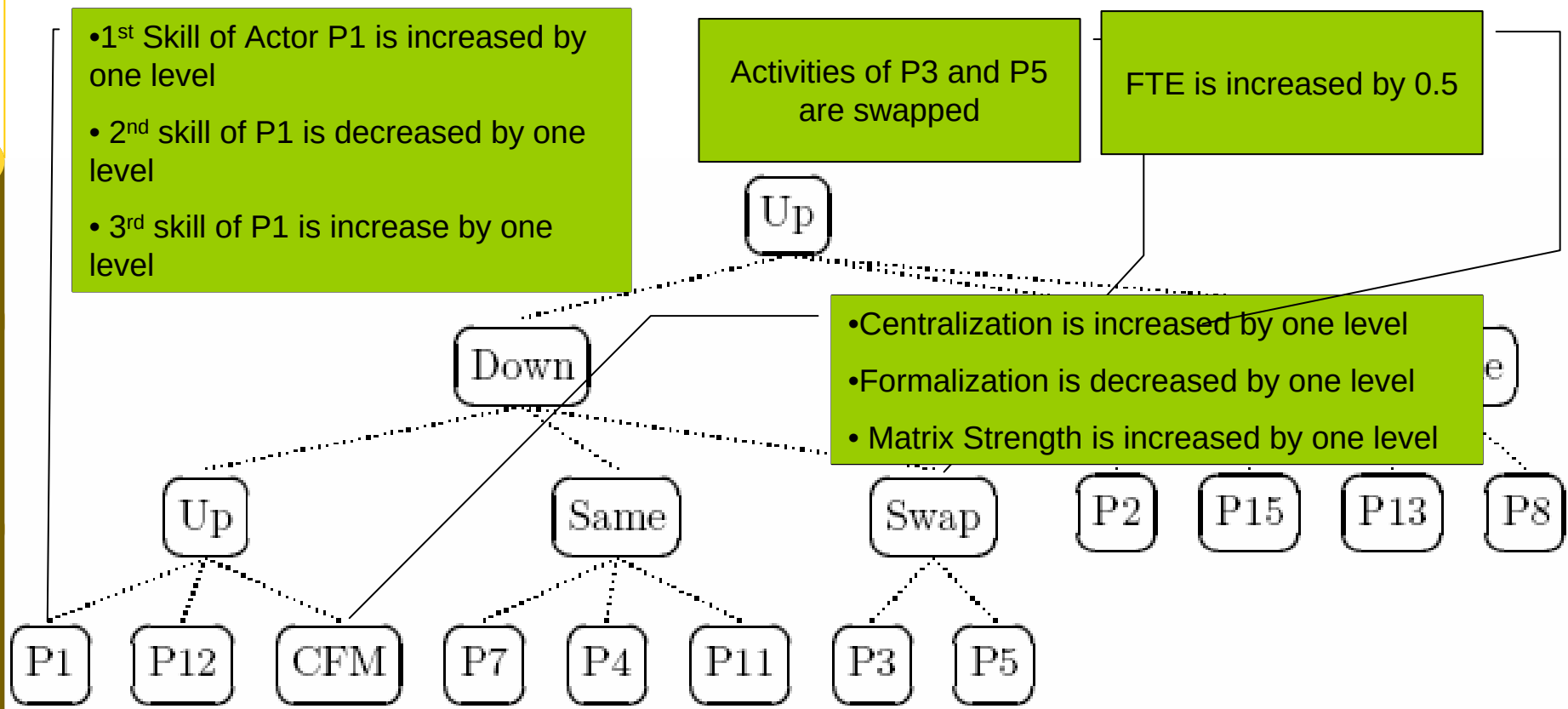
A Plausible Fitness Function for this Problem =

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

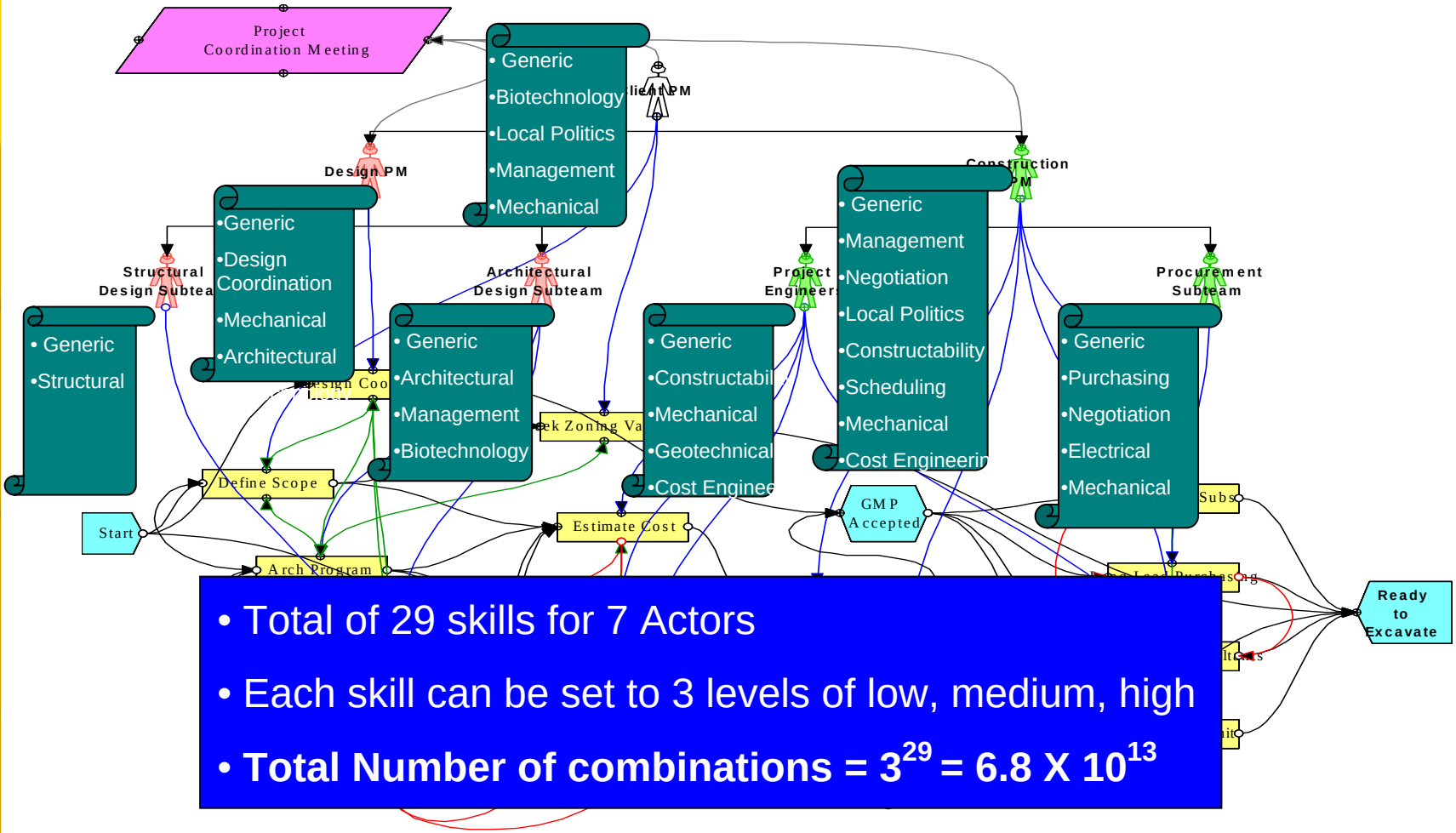
Where

- 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



Actors Skill Levels



Optimizing Actors Skill Levels

Genetic Tree Set up

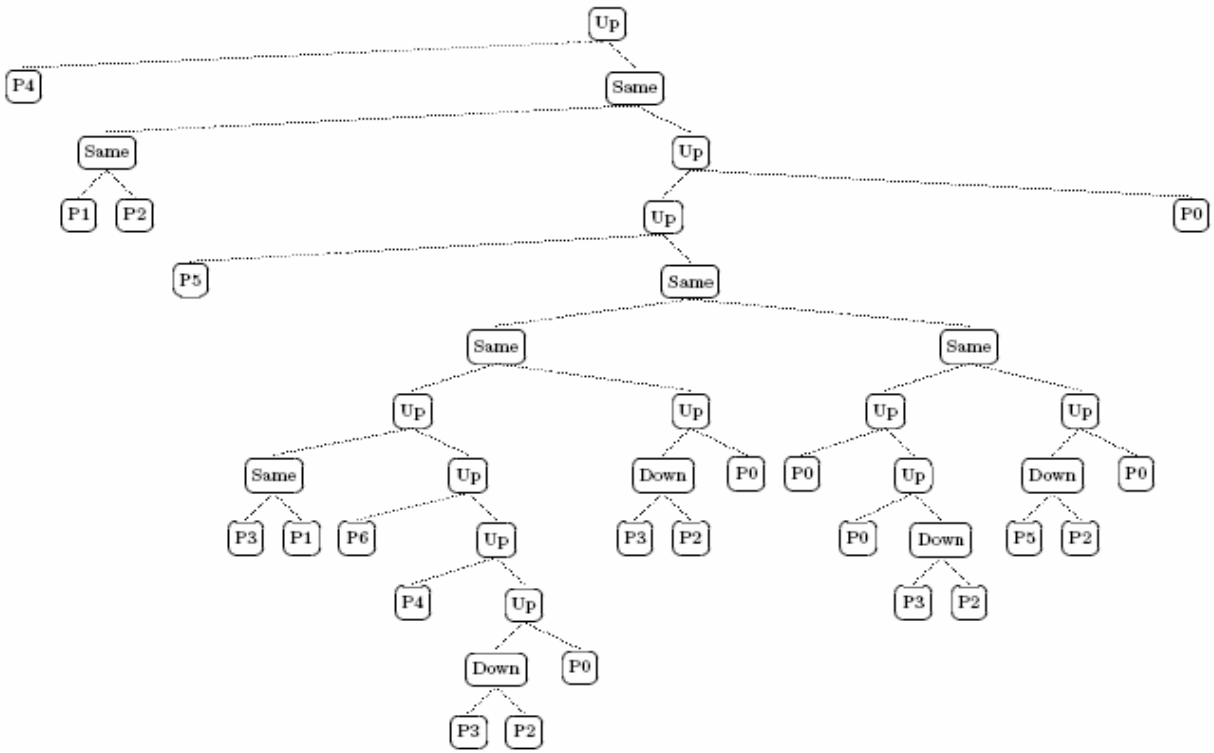
- Terminal Sets = {Up, Down, Same}
- Function Sets = {P1..P7}
- Population size M = 100
- Maximum number of generations = 50
- Crossover = 90% Mutation = 3% Reproduction = 7%

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

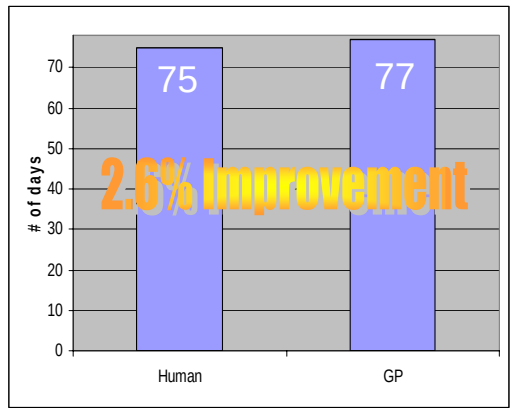
- **Genetic Tree Set up**
  - Terminal Sets = {Up, Down, Same, FTE, Assign, Aloc}
  - Function Sets = {P1..P7}
  - Population size M = 3000
  - Maximum number of generations = 100
  - Crossover = 90% Mutation = 3% Reproduction = 7%

Best Individual found after 21 generations

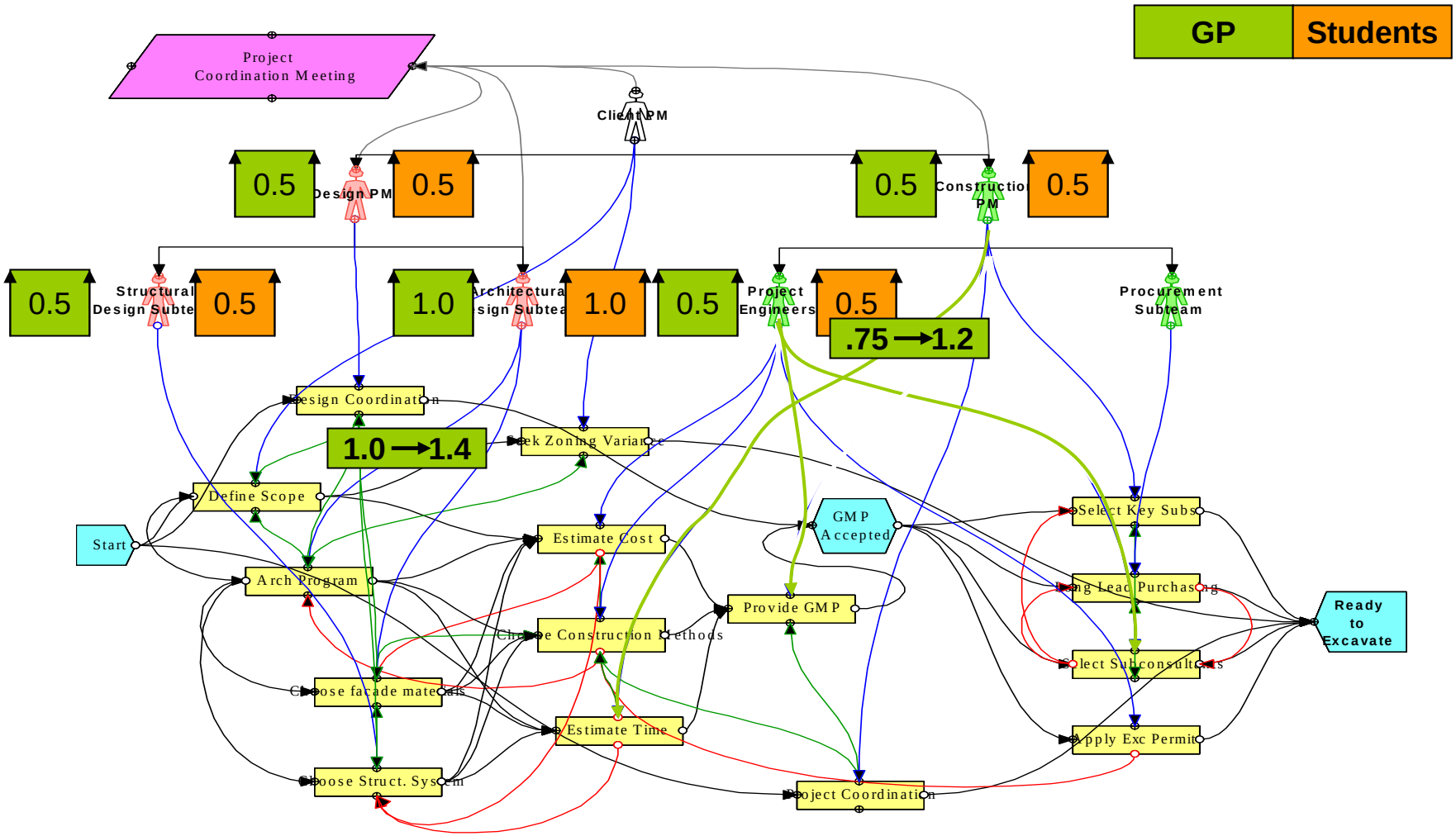
- Found Best Solution Ever!
  - Student/Manager Simulated End date=Dec 7, 2000
  - GP Solution Simulated End date = Dec 5, 2000

GP Solution:

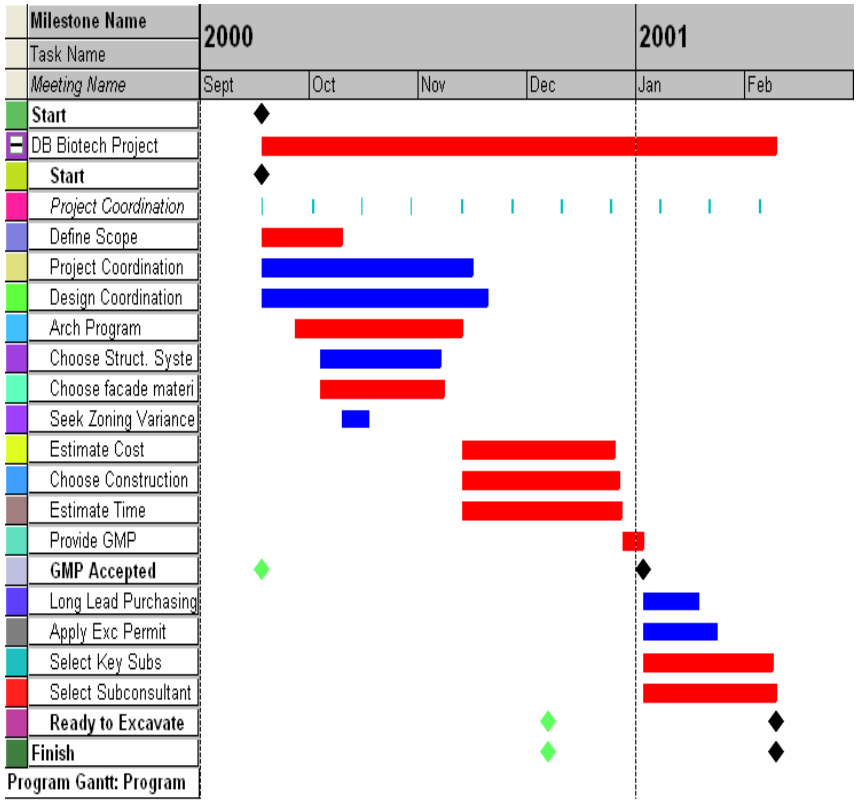
- Matched FTE additions additions in same location & same quantity
- Found additional Reassignment + changes in Attention Allocation



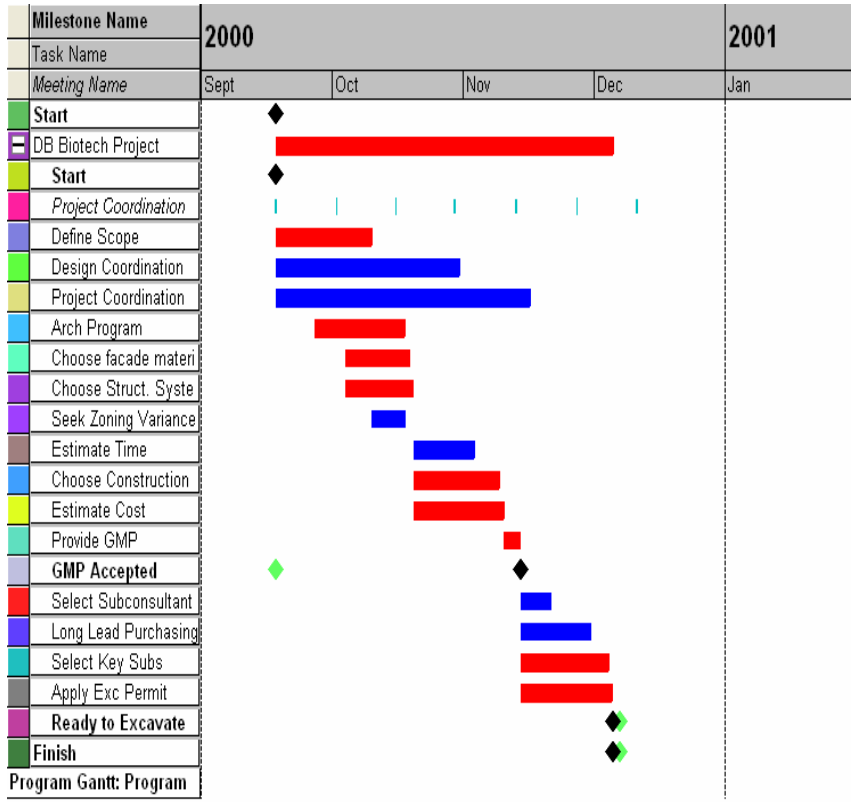
Comparing Assignments and FTEs Increments (GP vs. Student Solution)



Project Duration Improvement Before and After Intervention

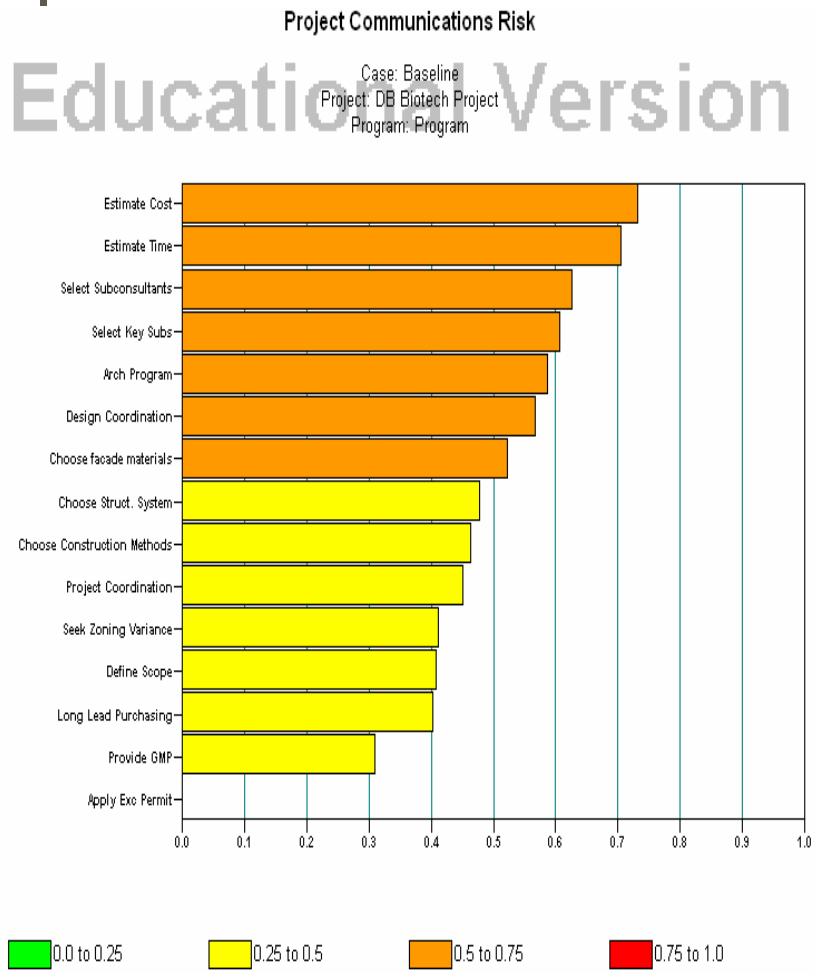


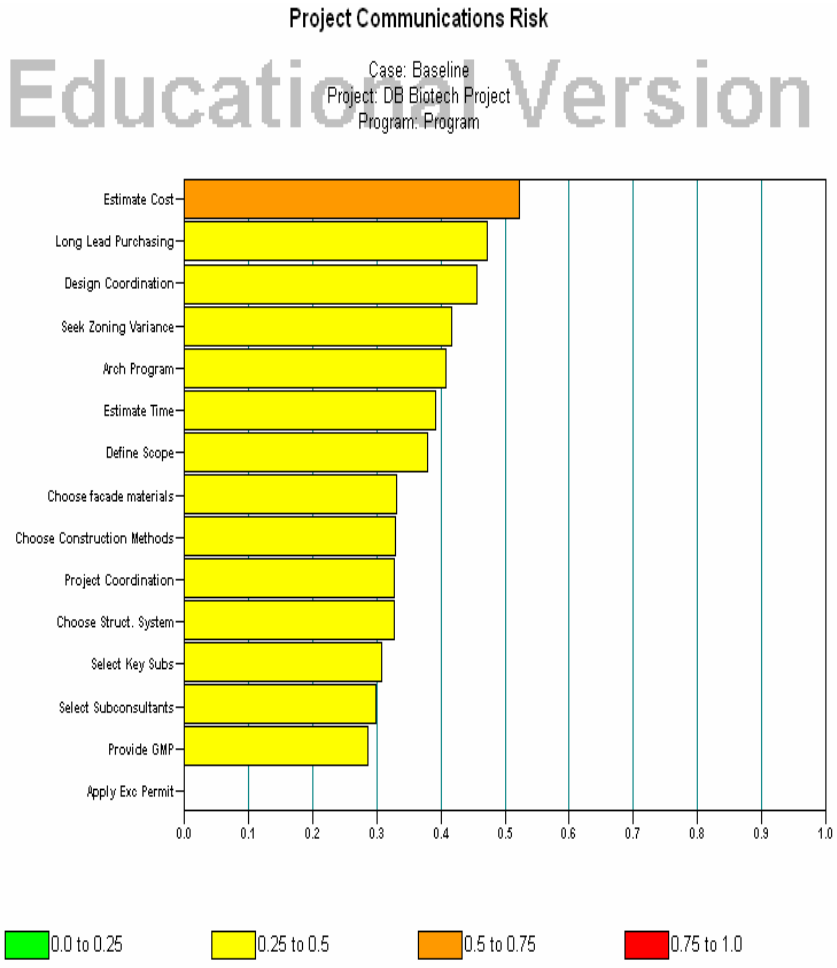
Before



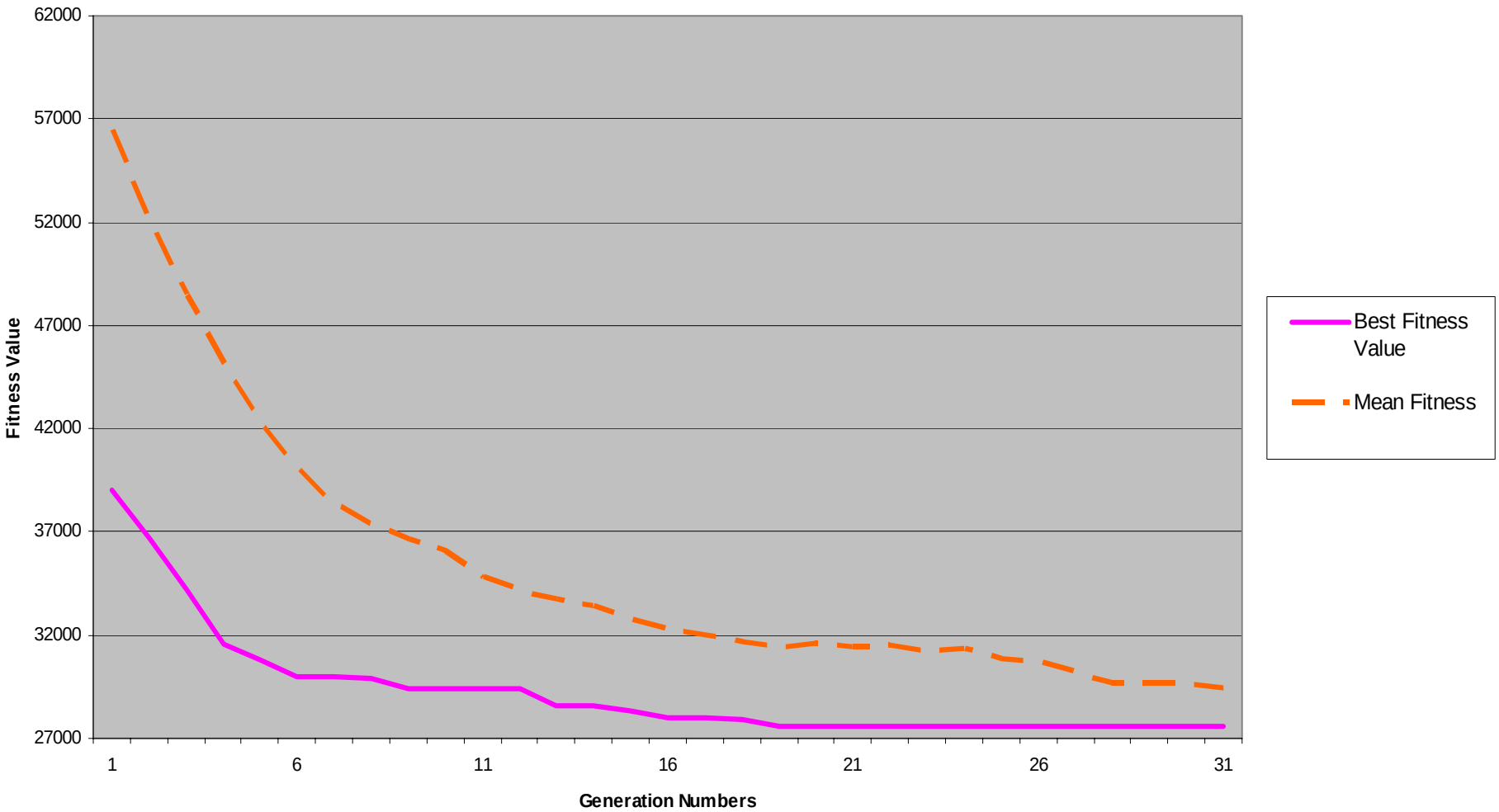
After

Quality Risk Improvement Before and After Intervention





Fitness Improvement thru Generations



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?