Novel Job Scheduling Tool for University Technology Transfer

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The Back Story

- **What is Technology Transfer?**
  - The transfer of inventions into the commercial marketplace
  - Includes
    - Evaluating invention disclosures for patentability and marketability
    - Applying for patent protection
    - Marketing the inventions to potential licensees
    - Negotiating the patent licenses
    - Collecting licensing royalty revenues
    - Maintaining the patent protection

The Back Story

- **Dr. Clovia Hamilton's background in technology transfer**
  - Member of the State Bar of Georgia, 1996
  - 1996-2003
    - US Patent and Trademark Office patent examiner
    - Registered patent attorney
    - Tech Transfer Specialist at the US EPA National Vehicle Fuel & Emissions Lab
    - Tech Transfer Specialist at the University of IL Champaign
    - Director of Intellectual Property & Compliance at Old Dominion University
  - Assistant Professor East Carolina University, 2003-2004
  - Adjunct Professor/ Lecturer Business Law & Ethics, 2005-2015

Job Scheduling tool is part of Dissertation Research

- PhD Industrial & Systems Engineering, Engineering Management University of TN Knoxville, 2016
  - Multi-paper dissertation entitled:

    A TOOL KIT FOR BUILDING HBCU TECHNOLOGY TRANSFER SUPPLY CHAIN NETWORKS USING AN ADVANCED PLANNING SYSTEM

    1. Use of correlations to inform the development of a model intellectual property policy
    2. Benchmarks using descriptive statistics
- Optimization of Resources
    3. Use of Linear Programming to optimize technology transfer resources - *published*
    4. Use of simulated annealing for a technology transfer Job Scheduling Tool

Job Scheduling Tool

Problem Statement: Alleviating University tech transfer delays

- Faculty complain that the tech transfer process takes too long
- When it takes too long, faculty may not be able to publish their findings
- Faculty publish or perish!!
- Timely market entrance of inventions is also important!
- First entrance advantage (Siegel 2003, Siegel 2007, Markman 2005)
- Evidence of delays in lit review

(Baldini, 2008; R. N. Feldman, Kris, 2008)

TECH TRANSFER TAKES TOO LONG!

Proposed Solution

- The Best value supply chains are agile and able to act rapidly in response to changes in supply and demand (Ketchen, 2008).
- Minimize delays with the use of a Job Scheduling Tool
  - Simple
  - Easy to use
- Use simulated annealing

TECH TRANSFER TAKES TOO LONG!

What is simulated annealing?

- Simulated annealing is an advanced optimization technique based on the physical process of crystallization.
- In this process, a substance is heated to a very high temperature and then cooled down slowly.
- When the energy has reached its minimum, perfect crystals are obtained.
- In a simulation of this annealing process, the algorithm begins with an initial solution, modifies the solution, and then continuously creates further solutions.
- These solutions are accepted for the next iteration with a certain probability.
- As in real annealing, the probability depends on a parameter called "temperature".
- With each iteration, the temperature is reduced.
- Since cooling down slowly increases the computing time, a tra
  off between solution quality and computing time has to be m
- When applied to detailed scheduling, it performs reasonably

(Kurbel, 2013).

TECH TRANSFER TAKES TOO LONG!

Simulated Annealing Optimization Technique

- Benefits of simulated annealing is that it:
  - can process functions that possess arbitrary degrees of nonlinearities, discontinuities, and stochasticity
  - can process quite arbitrary boundary conditions and constraints imposed on these functions
  - ***easy implementation*** with the degree of coding quite minimal relative to other nonlinear optimization algorithm
  - ***statistically guarantee finding an optimal solution***.

(Ingber 1993)

Job Scheduling Tool Development Research Approach

- Step 1 – Identify TTO job tasks to schedule
- Step 2 – Conduct job scheduling experiment using simulated annealing advanced optimization
- Step 3 – Conduct job scheduling using a commercially available job scheduling tool which uses Excel solver
- Step 4 – Compare the job schedule using the Excel solver tool to the simulated annealing tool

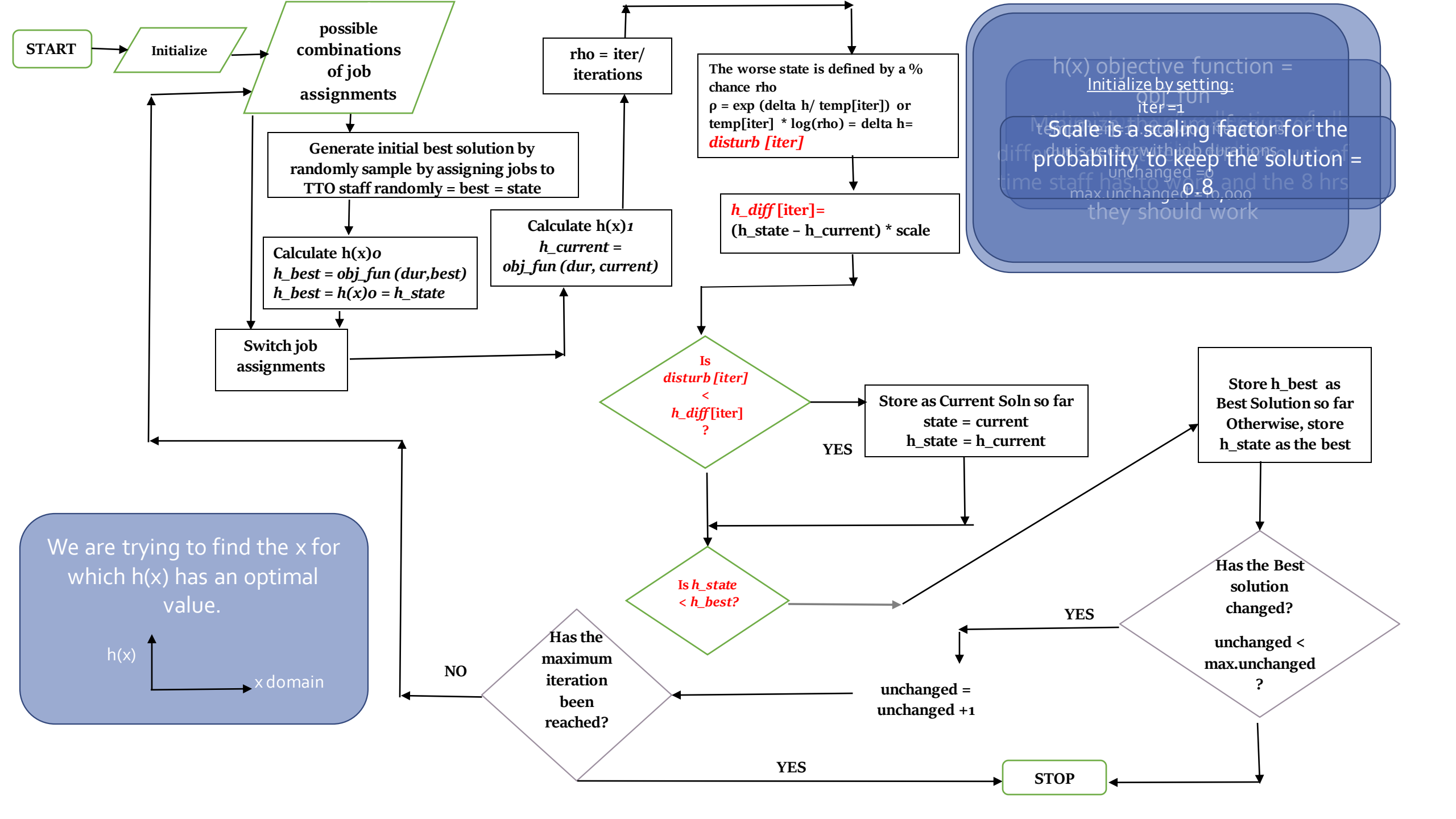
Step 2: Optimization Experiment -1

- First step – examine staffing

  Tech Transfer Office ***staffing*** (FTEs)
  - 72% have three or less staff
  - 12% have 10 or more FTEs (Swamidass 2009)
- Second step – examine staff ***job tasks***

Step 1 – Identify Tasks to Schedule University Tech Transfer Process

- Intellectual Property Policies & Legal Training
- Faculty Invention Disclosures
- Invention Disclosure Evaluations
- Patent Filing & Prosecution
- Marketing
- Licensing
- Royalty Revenue Collection


START
Initialize
possible combinations of job assignments
Generate initial best solution by randomly sample by assigning jobs to TTO staff randomly = best = state
Calculate h(x)o
h_best = obj_fun (dur,best)
h_best = h(x)o = h_state
Switch job assignments
Calculate h(x)1
h_current = obj_fun (dur, current)
rho = iter/ iterations
The worse state is defined by a % chance rho
ρ = exp (delta h/ temp[iter]) or temp[iter] * log(rho) = delta h= disturb [iter]
h_diff [iter]= (h_state – h_current) * scale
Initialize by setting:
iter =1
unchanged =0
max.unchanged = 10,000
Scale is a scaling factor for the probability to keep the solution = 0.8
Is disturb [iter] < h_diff [iter] ?
YES
Store as Current Soln so far
state = current
h_state = h_current
Store h_best as Best Solution so far
Otherwise, store h_state as the best
Is h_state < h_best?
Has the Best solution changed?
unchanged < max.unchanged ?
YES
unchanged = unchanged +1
Has the maximum iteration been reached?
NO
YES
STOP
We are trying to find the x for which h(x) has an optimal value.
h(x)
x domain

Results of Optimization Experiment - 1

Hypothetical scenario

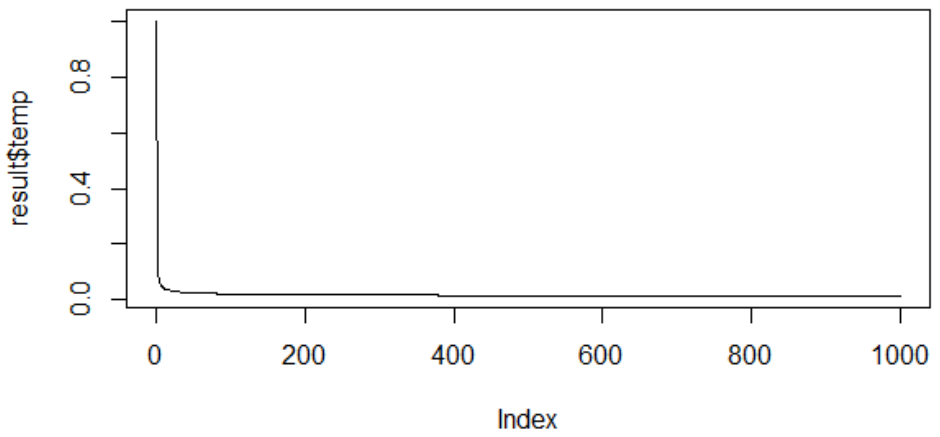
- 3 Person staff: Jane, Jim, Joan
- Complete the following tasks:

Job Tasks	Estimated Hours per task	Total hours
3 training seminars in 3 colleges	4hrs ea	12 hrs
3 invention disclosure evaluations	2 hrs ea	6 hrs
2 invention patent documents review	1 hr ea	2 hrs
3 marketing plans to create	2 hrs ea	6 hrs

Results

- Converges fast
- Coarse grain solution
  - Shows who will need to work overtime

```
> ##########
> # Show the solution
>
> employees <- c("Jane","Jim","Joan")
>
> jobs$employee <- employees[result$theta]
> tapply(jobs$time, jobs$employee, sum)
Jane  Jim Joan
   9    8    9
```



Optimization – Experiment 2 with this hypothetical list of jobs to schedule

Total of 11 jobs	Estimated time to complete	Total estimated required time (hrs)	Due Dates within one week	Day in the month
Complete 3 separate training seminars in 3 different colleges:	4 hrs each	12		
Training1			December 1	1
Training2			December 4	4
Training3			December 6	6
Evaluate 3 separate invention disclosures:	2 hrs each	6		
Disclosure1			December 3	3
Disclosure2			December 3	3
Disclosure3			December 4	4
Review patent prosecution documentation from outside patent counsel regarding 2 different inventions:	1 hr each	2		
Invention1			December 2	2
Invention2			December 4	4
Create marketing plans for 3 different patented inventions	2 hrs each	6	December 6	6
Plan1			December 1	1
Plan2			December 4	4
Plan3			December 4	4

Optimization Experiment 2 – Assumptions

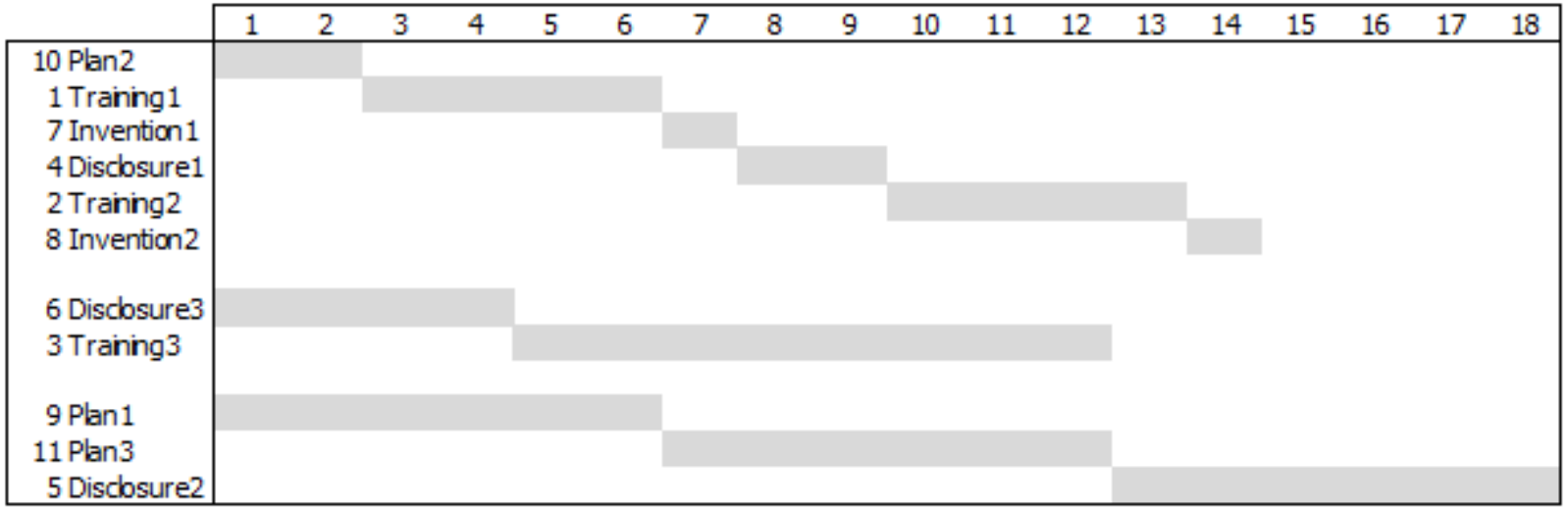
- All 11 jobs are available at time t=0. This is assumed to be the work start time on December 1, 2015. The jobs can be carried out independently, each by one person.
- Completion times of jobs are denoted i by C_i, i=1,…,11 and the corresponding due times by D_i, i=1,…,11. The due times are the days until deadlines multiplied by 8 hours work per day. The objective function to minimize is the total number of delays.

$$Z = \sum_1^{11} \min\left(0, \frac{C_i - D_i}{|C_i - D_i|}\right)$$

- An alternative objective function is the total idle time. This is defined as the sum of the times each person waits after he/she finishes, until all jobs have been completed.
- With regard to adjusting for speed, in the following, if $t_1, t_2, \ldots, t_{11}$ are the processing times required by person #1 for the 11 jobs, the processing times for person #2 are $2t_1, 2t_2, \ldots, 2t_{11}$ and the ones for person #3 are $3t_1, 3t_2, \ldots, 3t_{11}$.

Optimization Experiment

The Gannt chart is shown below.



Minimizing total delay: the Gannt chart with the solution.

Step 4: Compare Simulated Annealing Job Scheduling to Commercial Solver

- The simulated annealing job scheduler was compared to Edwin Straver's job scheduling tool
  - No feasible solution with the commercially available job scheduling tool
- With the right job scheduling optimization tool, tech transfer does not have to take too long

???

Any Questions?