Decision Analysis Newsletter

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Inside:

From The President

M. Elisabeth Pate-Cornell

Friends:

I want to thank everyone who attended our sessions in Atlanta. Unfortunately, I fell ill and couldn't attend, but we had a very successful track of presentations. Our track organizers, George Wu and Dana Clyman, did an excellent job attracting a broad range of speakers. Tragically, as you may know, Dana passed away shortly after the meeting. His energy and spirit will be missed. Both he and George have all our gratitude for the work they did for this meeting.

Highlights from Atlanta included a joint session with the Military Applications Society. As a result of active outreach effort, this session was well attended by members of both DAS and MAS. Our practice award was won by Colonel William K. Klimack and LTC (Ret) Jack Kloeber, Jr. Bob Clemen and Don Kleinmuntz distributed preview copies of the first issue of the *Decision Analysis Journal* which will be published in first quarter 2004, and our business meeting had over 80 members in attendance.

We are now the second largest society within INFORMS (after the Manufacturing and Service Operations Management Society), and with the launch of the *Decision Analysis Journal*, the society is on a good path forward. In order to continue on that trajectory over the next year, our society officers need to work with you, our membership, to determine our next major goal. In the meantime, please keep submitting your best work to the journal to ensure its long-term success.

From the Editor

Jay Sounderpandian

My term as the editor of *DAS Newsletter* was supposed to end with this issue. But on behalf of the DAS Council, Greg Parnell asked me if I would continue for one more year; and I agreed. I will continue till December 2004.

A change in editorship is always good. The Council and I would like to see somone else assume the editorship starting January 2005. If you are willing to be the editor, please contact Greg Parnell at

gregory.parnell@usma.edu.

The appintment is usually for a two-year term.

The job involves preparation of three issues per year using a suitable publication software, such as Adobe PageMaker (which I use). From my experience I can say that each issue takes about 10-15 hours spread over two weeks to collect all the materials and design the pages.

2003 DA Practice Award

L. Robin Keller

Congratulations to the winners, **William K. Klimack (**US Army) and **Jack M. Kloeber, Jr.** (US Army, Retired), for their important project on "Basic Combat Training Program of Instruction Review." They used a multidimensional value model to determine the overall value of each US Army Basic Combat Training task. The analysis led to the adoption of a number of recommendations. It also improved the definition of the objectives, highlighted training areas for increased command emphasis, and improved communication.

Congratulations to the finalists for their fine work:

Vish Viswanathan and **Rick Bayney** (Johnson & Johnson Pharmaceutical Research & Development, L.L.C.) conducted a project on "Decision Analysis to evaluate Proof-of-Principle Trial Design for a new drug: Value of information in a complex drug trial using a Bayesian approach."

Detlof von Winterfeldt (USC)**, Thomas Eppel,** (UC Irvine)**, John Adams** (Merrimack College)**, Raymond Neutra** (California Department of Health Services) and **Vincent Del Pizzo** (Public Health Institute, Oakland, California) conducted a project on "Managing Potential Health Risks from Electric Powerlines: A Decision Analysis Caught in Controversy."

Jeff Stonebraker (Bayer Biological Products), conducted a project on "Bayer's Drug Development Decision Process for Hemophilia A."

The judges for this year's competition were: **Roger Burk** (U.S. Military Academy, West Point), **Jim Felli** (Eli Lilly), **Bob Perdue** (Westinghouse) and **Bob Bordley** (General Motors). Evaluation criteria for the award included a) importance of the problem, b) impact on the client's decision making, c) benefits to the client organization, d) use of decision analysis tools, e) quality of the analysis, and f) originality. (Abstracts for the entire session are available at

https://informs.emeetingsonline.com/emeetings/formbuilder/
clustersessiondtl.asp?csnno=917&mmnno=113).

William Klimack and Jim Felli (Judge)

Jack Kloeber Jr. and Jim Felli (Judge)
[*How does Jim give exactly the same pose every time?*]

Detlof von Winterfeldt and Bob Perdue (Judge)

2003 DAS Awards

DAS Publication Award
Robert Nau

The Decision Analysis Society 2003 Publication Award (for best decision analysis publication appearing in the calendar year 2001) was presented to Han Bleichrodt (Erasmus University), Jose Luis Pinto (Pompeu Fabra University), and Peter P. Wakker (University of Amsterdam) for their paper "Making Descriptive Use of Prospect Theory to Improve the Prescriptive Use of Expected Utility" published in Management Science, Vol. 47, No. 11, November 2001.

Abstract: "This paper proposes a quantitative modification of standard utility elicitation procedures, such as the probability and certainty equivalence methods, to correct for commonly observed violations of expected utility. Traditionally, decision analysis assumes expected utility not only for the prescriptive purpose of calculating optimal decisions but also for the descriptive purpose of eliciting utilities. However, descriptive violations of expected utility bias utility elicitations. That such biases are effective became clear when systematic discrepancies were found between different utility elicitation methods that, under expected utility, should have yielded identical utilities. As it is not clear how to correct for these biases without further knowledge of their size or nature, most utility elicitations still calculate utilities by means of the expected utility formula. This paper speculates on the biases and their sizes by using the quantitative assessments of probability transformation and loss aversion suggested by prospect theory. It presents quantitative corrections for the probability and certainty equivalence methods. If interactive sessions to correct for biases are not possible, then the authors propose to use the corrected utilities rather than the uncorrected ones in prescriptions of optimal decisions. In an experiment, the discrepancies between the probability and certainty equivalence methods are removed by the authors' proposal."

DAS Student Paper Award
Jeff Keisler

Franz Heukamp, now on the faculty of the IESE Business School, University of Navarra, won the award for his paper, "Stochastic Dominance and Cumulative Prospect Theory: Theory and Experiments" (written with previous prizewinner Manel Baucells!). Franz received a beautiful plaque and a check for $500.

Erin Baker, now on the faculty of the University of Massachusetts at Amherst, was a clear runner-up and received a plaque in recognition of her paper, "Increasing Risk and Increasing Informativeness: Equivalence Theorems".

Ali Abbas, Luiz Brandao and **Seth Guikema** were also selected as finalists from a strong field of 18 total submissions.

Jeff Keisler & Jeff Stonebraker co-chaired the competition, with much help and guidance from previous competition chair John Butler. Jim Dyer, Laura Kornish, Prakash Shenoy and George Wu served as judges.

Jeff Keisler and Franz Heukamp

Erin Baker and Jeff Keisler

Decision Analysis Launch Update

Bob Clemen and Don Kleinmuntz

Plans for the March 2004 launch of *Decision Analysis* are now largely complete. Members of DAS and INFORMS saw tangible evidence of this at the Atlanta INFORMS meeting in October, where INFORMS staff distributed a preview issue that included some of the articles to appear in the first issue. The centerpiece was an article by Don Keefer, Crag Kirkwood, and Jim Corner reviewing decision analysis applications since 1990. Comments by Scott Cantor and Raimo Hämäläinen and a response by Keefer, et al, rounded out the preview issue.

In addition, INFORMS is featuring articles that will appear in *Decision Analysis* at

http://pubsonline.informs.org/feature/.

At the time we wrote this column for the newsletter, the articles mentioned above were available for anyone to download. Over the next six months, this website will also feature other articles that are scheduled to appear in *Decision Analysis*. Be sure to visit the website to see what's coming up!

Excerpts from the Clemen and Kleinmuntz Editorial

The preview issue included an editorial by editors Clemen and Kleinmuntz, which will also appear in the first issue. The article by Keefer and colleagues as well as the commentaries on it raised a critical question for the new journal: What are the appropriate boundaries that determine when a method or technique is decision analysis and when it is not. As editors, we felt it was incumbent upon us to explain where we came down in the debate. For two years we have been making decisions regarding whether particular submissions were appropriate for the journal, and we took this opportunity to state our criteria explicitly. Here are several key quotes from the editorial:

"Inside the back cover of this and every issue of the journal you will find a statement of editorial objectives. The crucial sentence from that statement is, 'The primary focus of the journal is to develop and study operational decision-making methods, drawing on all aspects of decision theory and decision analysis, with the ultimate objective of providing practical guidance for decision makers.' We find this statement compelling because it provides guidance in two ways. First, contributions to the journal must be faithful to the intellectual foundations of decision theory and decision analysis. Second, articles must demonstrate relevance to the practical spirit of decision analysis, a field dedicated to using models to analyze and understand real decision problems, and ultimately, to improve real decisions.

"These two points should not be interpreted too narrowly, however. For instance, we are *not* saying we will only publish applications, or only consider contributions following

a conformist interpretation of decision analysis. Rather, we hope to see diverse contributions, including some that genuinely challenge and advance the theoretical foundations of our field. For example, we hope to publish articles that bring aspects of the psychology of judgment and decision making to bear in very specific ways in order to improve decision analysis's prescriptive methods. Another example is research that focuses on decision theory and decision-analysis practice in organizational contexts. A third example concerns the interplay between game theory and decision analysis: What role can or should game-theoretic concepts play in decision analysis, especially in accounting for the actions of other decision makers who are reacting strategically to our own decisions? This list is far from exhaustive, and we welcome unique and original contributions that bring any number of other disciplines to bear. We conceive of *Decision Analysis* as a vehicle for advancing and blending both theory and practice, promoting the dissemination of decision analysis in academia and in the world at large, and connecting DA researchers, teachers, consultants, and practitioners. A key measure of our success will be increased recognition of decision analysis as a field and ultimately greater utilization of decision analysis."

We receive many submissions that propose new methods aimed at helping decision makers. Not all of these proposed methods are consistent with the underlying principles of decision theory. Where should we draw the line? In our editorial, we stated our position as follows:

"We have no desire to proscribe [proposed] methods based on an initial and perhaps naïve assessment that they represent 'ad hockeries' that fail to conform to some existing canon of decision analysis theory and practice. Nor do we desire to indiscriminately admit any and all methods that might be used to make a decision. Rather, our position stems from the observation that the theoretical underpinnings of decision analysis are both strong and compelling. Therefore, novel proposals should either conform to those theoretical underpinnings, or, if not, they should be directly compared to existing decision-analytic methods. The nature of the comparison may vary depending on the contribution, for instance formal theoretical development and argumentation in some cases or compelling empirical demonstration in others. As a practical matter, the field of decision analysis should never permit dogmatic skepticism to stand in the way of potentially valuable improvements, but likewise, the current body of decision analysis knowledge rests upon almost fifty years of theoretical and practical developments that provide a sound basis for moving forward."

We believe that our view is generally consistent with that of the DAS membership, and we certainly believe that it sets the stage for *Decision Analysis* to become the premier outlet for innovative research in our field. We hope you agree and that you will send us your best work!

Working Papers Received

Title: Maximum Entropy Utility
Author: Ali Abbas

This paper presents a method to assign utility values when partial information is available about the decision maker's preferences. We introduce an analogy between probability and utility through the notion of a utility density function and illustrate the application of this analogy to the maximum entropy principle. We discuss the implications of "maximum entropy utility" on the preference behavior of the decision maker and provide new interpretations for utility functions that are commonly used in practice. We extend the analysis to the case of multiple attributes and work through several examples to illustrate the approach.

Title: Attribute Dominance Utility:
Authors: Ali Abbas and Ronald. A. Howard

This paper presents an analogy between a joint cumulative probability distributions and a class of mutliattribute utility functions which we call attribute dominance utility. Attribute dominance utility functions permit assessing multiattribute utility functions using common techniques of joint probability assessment, such as marginal-conditional assessments and the method of copulas. We introduce the notion of utility inference analogous to Bayes' rule for probability inference and provide a graphical representation of utility functions, which we call utility diagrams.

Title: Utility - Probability Duality
Authors: Ali Abbas and Jim Matheson

This paper introduces duality between probability distributions and utility functions. The primal problem is to maximize the expected utility over a set of probability distributions. To develop the dual problem, we scale the utility function between zero and one, so that it obeys the same mathematical properties as a (cumulative) probability function. We show that reversing the roles of the two functions in the expected utility formulation provides a natural "dual" problem. Many of the known results for the primal problem can be reinterpreted in the dual problem. For example, we introduce a new quantity, the aspiration equivalent, as the "dual" of the certain equivalent. The aspiration equivalent provides a new method for choosing between lotteries and a win-win situation for principal-agent delegation when used as a target. We also show several new dual results such as utility dominance relationships as dual to stochastic dominance relationships and introduce a new saddle-point method for allocating lotteries to decision makers.

ITE Journal

Patrick Noonan

From my experience, not only is the membership of the DAS involved in some of the most interesting and important research within the broader OR/MS community, but it includes some of the most successful educators.

This is partly because our field attracts such cool people, of course. But let's be honest — it's also our material. Our decision-centric view of the world is a terrific way to motivate & frame issues of importance to students of management, engineering, health sciences, policy, and so forth.

That's one reason why many of us are involved in courses that win teaching awards, while some other valuable parts of the OR/MS family sometimes face tougher challenges.

As a member of the Editorial Board of *INFORMS Transactions on Education* (ITE), I strongly encourage my fellow decision analysis educators to share some of their great talent, great experience and great material with the rest of the community.

In the first few years of this journal, our editors actively & extensively explored the potential for this new electronic medium. I believe that the period of experimentation and learning has led to a new format that can be a great platform for exchange of ideas relating to OR/MS education.

Although the ITE is looking for high-quality material, it is not a cut-throat competition journal that aspires to low acceptance rates. In fact, our editors work with authors to turn as many submissions as possible into publishable material. We also have a good record of quick turnaround.

The type of material we're looking for is quite varied:
— case studies and case articles
— review and opinion articles
— spreadsheet applications
— discussion of the impact of new technologies
— new methods of assessment
— curriculum development
— tutorials and classroom-oriented surveys
— education surveys
— games and puzzles
— reports on controlled experiments
— reviews of software, books, and teaching materials

In fact, you probably have some high-quality instances of these already in your files, on the drawing board, or in the back of your mind — just waiting for the right place to put them. We hope you'll direct them our way!

Please visit the ITE journal site at
http://ite.pubs.informs.org/index.php
and take a look at the Instructions to Authors page
http://ite.pubs.informs.org/info/authors.php
for more details.

Thanks for your consideration. We look forward to hearing great things from you.

DA Journal - Call for Papers

Decision Analysis

Special Issue on Graph-Based Methods for Decision Analysis

Decision Analysis, INFORMS's newest peer-reviewed journal, is soliciting submissions for a special issue on graphical models for representing and reasoning about decision problems in decision analysis, computational sciences, and affiliated fields. Articles may focus on theoretical foundations and/or real-world applications and experiences with graphical models for decision making, including influence diagrams, Bayesian networks, and related representations. Dr. Eric Horvitz of Microsoft Research will serve as guest editor for the special issue, tentatively scheduled for publication in 2005.

Special Feature: "Influence Diagrams" by Howard and Matheson

As a centerpiece for the special issue, we plan to publish the classic manuscript "Influence Diagrams" by Ron Howard and Jim Matheson. Although this paper has had immense impact since it was written in the late 1970s, it received only limited distribution and has never appeared in the open literature. We hope that this long-awaited archival publication of "Influence Diagrams" will inspire current researchers to submit outstanding original contributions that reflect the current state of the art in graph-based methods and applications.

Submission Information

Authors interested in submitting manuscripts for consideration in the special issue should send a proposed title and abstract by March 1, 2004, and submit the full manuscript by May 1, 2004. Both abstracts and final papers should be sent by email attachment to guest editor Eric Horvitz (horvitz@microsoft.com) and, simultaneously, to Bob Clemen (clemen@mail.duke.edu), co-editor-in-chief of the journal. All submissions will be peer reviewed. For information about the journal, including instructions to authors, please visit

http://da.pubs.informs.org.

We also encourage authors to review the journal's editorial objectives below and to ensure that submissions are suitable for the journal in both style and substance.

Editorial Objectives

Decision Analysis is dedicated to advancing the theory, application, and teaching of all aspects of decision analysis. The primary focus of the journal is to develop and study operational decision-making methods, drawing on all aspects of decision theory and decision analysis, with the ultimate objective of providing practical guidance for decision makers. As such, the journal aims to bridge the theory and practice of decision analysis, facilitating communication and the exchange of knowledge among decision analysts in academia, business, industry, and government. Articles will contribute to these goals in many ways, using a wide variety of methods and approaches. Appropriate topics include the discussion of new or existing algorithms, procedures, or processes for implementing decision analysis; cognitive, organizational, or social issues in applying decision analysis; innovative uses of information technology to perform decision analysis; issues in applying decision analysis to real-world situations; and other topics that further the theory and practice of decision analysis. The journal also publishes articles that review and summarize important topics or advances of interest to decision analysts or that provide original historical, scholarly, or practical perspectives on the field. In addition, the journal encourages articles that support the teaching of best practices, such as state-of-the art applications, case studies, and tutorial articles on decision-analysis methods

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Our Friend and Colleague, Dana Clyman

Sam Bodily

Dana Clyman

Dana Ross Clyman died November 11, 2003, at the University of Virginia Hospital. He had experienced an arrhythmic heart event while riding his bicycle on November 1 after which he never regained consciousness. He was 51.

Dana was an Associate Professor in the Darden Graduate Business School at UVA, where he taught decision analysis, quantitative analysis, negotiation, and multiparty negotiations in the MBA program. In addition, he designed and taught a number of executive education programs for Darden and a number of corporations, both domestic and international. He was a visiting scholar at IESE in Barcelona.

The Decision Analysis society gained from Dana's service as a member of the council, on the founding editorial board of the new journal *Decision Analysis,* as an organizer of many sessions of INFORMS, and as co-chair of the Decision Analysis cluster of the meetings just completed in Atlanta. He authored many articles and cases in decision analysis, negotiations, finance, and teaching. See Dana's web page:

http://faculty.darden.virginia.edu/
clymand/index.htm

His commitment to teaching was recognized by the Darden student body when he was the 1994 recipient of the Outstanding Faculty Award.

Dana had two decades of general management and consulting experience in the financial- and computer-services industries. He also worked with Cresap, McCormick and Paget, an international general management consulting firm, and in senior management positions at Hogan Systems, Bank-Pro systems, and Crescendo systems—software companies serving the banking industry. He was a director of FINEX, a subsidiary of the New York Board of Trade.

Dana received his bachelor's degree from New College; his master's from Dartmouth College; his MBA from Stanford University; and his Ph.D. from Harvard University and the Harvard Business School.

Those who know Dana will remember his great exuberance for life, his great intellect, his passion for negotiations, his concern for students and, most importantly, his great love for family and friends. Dr. Robert Clyman said of his older brother, "Dana had a sense of engagement, a sense of infectious enthusiasm—when you were around him you became as excited as he was." Clyman also said, "Dana loved to teach and really found his niche at Darden."

Dana is survived by his wife and son, Lisa and Aaron. A memorial service, aptly titled a *Celebration of Life for Dana Clyman*, was held at The Darden School on November 14. Over 600 people attended—including numerous family members, friends, students and colleagues—from near and far. Several members of the DAS, graduate school colleagues of Dana, were in attendance.

In the service, Professor Sherwood C. Frey, Jr. recalled his first meeting with Dana, when the latter was being recruited by the school. When Frey asked how he would choose among the many offers from competing institutions, Dana replied, "I want to go where I will have the most fun." Frey said that Dana was a great collaborator and noted how much the two friends had enjoyed working together for the last decade. "We would sit next to each other and collectively compose and whenever we would finish teaching an executive education course," Frey said, "we would always shake hands or embrace and say, 'good job, my friend.'"

A neighbor recalled that while Lisa Clyman was pregnant with Aaron, Dana had difficulty imagining how he would be able to connect with his infant son, who would be unable to speak. Dana's fears on this point were unfounded, reported the friend, who will always remember Dana telling her, "The instant I saw Aaron, I fell completely in love."

Darden first year students spoke on behalf of their section C colleagues in Dana's Quantitative Analysis course: "He had a genuine interest in our development…every second counted for him." "Dana taught his course as if he were conducting an orchestra—he was interested in everybody's role."

Dana's greatest joy was in teaching things to his son Aaron and in having Aaron teach him things, like how to play the piano. It was said of Dana that "As Aaron got older, Dana got younger."

In his memory, the family has established The Dana R. Clyman Scholarship Fund at Darden. Contributions can be sent, payable to the Darden School Foundation (noting that the contribution is for the Dana R. Clyman Scholarship Fund).to:

The Dana R. Clyman Scholarship Fund
C/O Darden School Foundation
P.O.Box 7726
Charlottesville, VA 22906-7726

Answers to Items from Previous Issue

Jayavel Sounderpandian

1. A Motto for Project Managers

Correct solutions were received from **Michael L. Jones, Itzhak Ravid,** and **Scott Cantor.** I received an anonymous correct solution as well. The solution:
THE SOONER YOU FALL BEHIND SCHEDULE, THE MORE TIME YOU'LL HAVE TO CATCH UP.

2. Give Me a Sign

Michael L Jones and **Itzhak Ravid** gave the correct answer that all 25 signs can be salvaged. But they did not supply a proof. Here's my proof:

This is an application of bipartite matching, cleverly disguised. Draw a node EN to denote English North and HN to denote Hindi North; Nodes ES, EE, EW, HW, HE and HW are drawn similarly. If a sign has EN on one side and HN on the other draw an edge from EN to HN and so on for each sign. The resulting graph is bipartite and 25-regular (each node has degree 25). Any n-regular graph satisfies Hall's condition, and therefore by Marriage Theorem a maximum matching is possible. Thus, one will be able to find four signs that have all four directions in both languages. After removing one such set, the same conditions and theorems apply and one will be able to find one more set of four signs and so on until all sets are salvaged.

3. Clean Sweep

Itzhak Ravid and **Scott Cantor** submitted correct solutions. Itzhak pointed out that there are other versions of checkers as well, and therefore other soutions. I had, of course, meant the US Checkers rules. The solution is:
1. 23-27, 31-24
2. 18-22, 25-18
3. 9-5, 2-9
4. 5-14-23-16, 20-11
5. 28-19-10-3, 11-8 (or 7)
6. 3-12 (or 10). Black wins.

GMAA - A Decision Support System

Sixto Rios-Insua

The **G**eneric **M**ulti-**A**ttribute **A**nalysis (GMAA) System is a *Decision Support System* (DSS) based on an additive multi-attribute utility model that accounts for incomplete information concerning the inputs and is intended to allay many of the operational difficulties involved in the *Decision Analysis* cycle.

The user can interactively create or delete nodes and branches to build or modify an objectives hierarchy. Alternatives and their consequences, in terms of the attributes associated with the lowest-level objectives, can be easily entered by hand or loaded from file. The system admits uncertainty about consequences.

The system also admits incomplete information about the DM's preferences through value intervals as responses to the probability questions the DM is asked, which leads to classes of utility functions and weight intervals. This is less demanding for a single DM and also makes the system suitable for group decision support.

The different alternatives under consideration can be evaluated by means of an additive multiattribute utility function. The additive model is used to assess, on the one hand, average overall utilities, on which the ranking of alternatives is based and, on the other, minimum and maximum overall utilities, which give further insight into the robustness of this ranking. It is also possible to select another objective to rank by. The system provides different displays of ranking results: *Stacked Bar Ranking, Measure Utilities for Alternatives*, *Compare Alternatives Graph* and *Paired Attributes Correlation*.

Finally, the system provides several types of Sensitivity Analysis (SA), like classical SA, which involves changing the parameters and observing their impact on the ranking of alternatives, or the assessment of *weight stability intervals*. The assessment of *non-dominated* and *potentially optimal* alternatives and the application of *Monte Carlo* simulation techniques take advantage of the useful imprecise information collected during the assignment of the component utilities and weights and the uncertain alternative consequences entered.

In some cases, the information obtained from the alternatives evaluation is not meaningful enough so as to definitively recommend an alternative. In these cases, the above techniques play a very important role. They may provide more meaningful information, and an iteration process can be carried out by tightening the respective imprecise alternative consequences, component utilities and weights and reassessing the non-dominated and potentially optimal alternatives or performing the Monte Carlo simulation techniques again, until a dominant strategy is found. See

www.dia.fi.upm.es/~ajimenez/GMAA

The Provocative Page

Jayavel Sounderpandian

E-mail your solutions to the puzzles on this page to me (souderp@uwp.edu) before March 1, 2004. Names of those who submit correct answers will be mentioned in the Decmber issue.

1. Ron Howard, the Director

What did Ron Howard tell Jeff Keisler? Solve the cryptogram to find out.

Photo by George Wu

"E'SS STN PAY FA NOEL NEXT. MYN

CAD'N PAY TRTH REASUNT TY*

UBEAXL UFUED!"

*This word is an acronym

2. Money Trees on Groves

A grove has apple trees planted at square lattice points where two neighboring trees are 10 feet apart. [There is a tree at every point, and only those points, with coordinates $(10x, 10y)$ where x and y are integers. The coordinates are measured in feet.] You can lease any area of the grove at a cost of $5 per square feet per month. The leased area must have a polygonal shape with a tree at each vertex of the polygon. You get a revenue of $500 per month from any tree that is inside the leased area and $250 from any tree on its perimeter. Assume that there are no costs other than the lease. You naturally wish to maximize your monthly profit. Find a polygonal area that maximizes your profit.

3. Heat Transfer

You wish to take a bath in water at 95 degrees Fahrenheit. You have two bathtubs, each with a capacity of 36 gallons. In one othem you have 27 gallons of water at 90 degrees and in the other you have 24 gallons of water at 100 degrees. You have an empty pail that has a capacity of 1 gallon, which you can use to transfer water from one tub to the other. A "move" consists of transfering an integral number of gallons of water from one tub to the other. Assume that no heat is lost throughout the moves and waters mix evenly. You have no other sources of water or heat.

a. Find a way to get a full tub (36 gallons) of water at 95 degrees, in minimum number of moves.

b. If you can transfer non-integral amounts of water, can you do it in fewer moves?

c. What are the possible temperatures one can achive in a full tub if any number of moves and non-integral amounts of transfer are allowed?

Doodling space