INTERNATIONAL INDUSTRIES, INC.

International Industries, Inc. is a $53 billion conglomerate that owns and runs a wide variety of businesses worldwide. The scope of these businesses (which are called "divisions" at International Industries) ranges from retail packaged foods to industrial machine tools to financial services. George Ye has been CEO of International Industries for the past six years. At a recent meeting of the Board of Directors, Mr. Ye had come under criticism for International Industries' poor performance in the last two years. In particular, the Board felt that Mr. Ye was not decisive enough in selling divisions that had been under performing, and that he was also not aggressively investing in new businesses (particularly in the computer and bio-technology sectors). To his credit, Mr. Ye had closed four divisions during his tenure as CEO (which were smart moves, even in hindsight), and he had invested more than $2 billion in a new worldwide-web-based internet division, and more than $1 billion in a new division involved in the development of industry-oriented financial software.

After the Board of Directors meeting, George Ye arranged a meeting with the Chief Financial Officer (CFO) of International Industries, Mr. Paul Glasser. George Ye asked Mr. Glasser to undertake a comprehensive re-evaluation of all of the divisions of International Industries. More specifically, he asked Mr. Glasser to recommend to him which divisions to sell, which divisions merited further investment of capital, and which should be maintained at status quo. Furthermore, he wanted this analysis completed within the next two months, in time for the next quarterly meeting of the Board of Directors.

Mr. Glasser retained the services of the consulting firm GCG, Inc. for assistance in this decidedly large and important undertaking. Mr. Glasser asked the directors of each of the fifty divisions of International Industries to submit a request for capital expenditures (with justification and back-up). For each division, Mr. Glasser wanted to decide whether International Industries should further invest in the division, maintain the division with no significant additional investment, or sell the division. Of course, it would also be nice to consider other investment options for each division, such as investing more or less than the requested amount, but with only two months to complete his analysis, Mr. Glasser honestly thought he would have to keep his decision framework purposely limited in scope.

For each of the fifty divisions and for each of the three decision choices (invest, maintain, or sell), Mr. Glasser asked the division vice president to report the investment amount required, the expected financial implications of the choice (measured in net present value (NPV)), and the cash flow implications of the choice for the coming year. With the help of the GCG consultants, each of the fifty divisions submitted the requested information. For example, consider the tool and die manufacturing division, which is division number 2. The summary information for division 2 is shown in Table 9.14. The plan to invest in this division consists of building a new factory in Mexico, buying new machinery, buying new computer systems, and expanding warehousing capacity. The plan to maintain this division merely requires upgrading obsolete equipment. The plan to sell this division involved funds expended for canceling leases and contracts and for severance packages for higher-level managers. The spreadsheet INT-INDUSTRIES-DATA.XLS contains all of the information collected by GCG for all 50 divisions.

TABLE 9.14
The investment required, net present value, and cash flow for next year for each of the three choices (invest, maintain, and sell) for the tool and die manufacturing division, which is division 2.

Choice	*Investment Required (in $ million)*	*Net Present Value (in $ million)*	*Cash Flow for Next Year (in $ million)*
Invest	300	−257	−200
Maintain	40	−16	35
Sell	400	1,100	1,600

Mr. Glasser needed to determine which decision (invest, maintain, or sell) to recommend for each division. His decision criterion was to maximize the net present value to International Industries, subject to cash flow considerations. The cash-flow considerations were that the total investment amount for next year could not exceed the total cash flow for next year.

Mr. Glasser also identified some choices that were interrelated, which he listed as follows in his discussions with GCG:

(a) For strategic reasons, if International Industries sells division 1, then they should invest in division 2 and vice versa. Similarly, if International Industries sells division 1, then they should sell division 3 and vice versa. Finally, if International Industries sells division 1, then they should sell division 4 and vice versa.

(b) If International Industries invests in division 6, then they should also invest in division 7 and vice versa.

(c) For diversification purposes, Mr. Glasser felt that at most one of the following choices could be made: sell division 3, sell division 4, sell division 5, maintain division 6, sell division 7, and sell division 9.

(d) Similarly, Mr. Glasser felt that at most one of the following choices should be made: invest in division 4, maintain division 6, sell division 2, sell division 6, sell division 8, sell division 12, and invest in division 14.

(e) Given the similarities of divisions 24 and 28, Mr. Glasser felt that if International Industries invests in division 24, then they should also invest in division 28.

(f) Similarly, if International Industries maintains division 30, then they should either maintain or invest in division 32.

Given that there are three choices for each of the fifty divisions, Paul Glasser realized that there were $3^{50} \approx 7.1 \times 10^{23}$ possible investment strategies to consider, which of course is an astronomical number. When he discussed this with the consultants at GCG, they pointed out to him that they thought they might be able to compute the optimal investment strategy by formulating and solving the decision problem as a discrete optimization problem. Mr. Glasser knew that even if he found the "optimal decision strategy" George Ye would most certainly ask him about the sensitivity of his decision to key financial assumptions. From previous experience, Paul Glasser also knew that George Ye would ask him not only for his "optimal" recommendation, but he would also ask Paul for his second-best and third-best alternative recommendations, etc.

Assignment:

(a) Suppose that you are an associate of the firm GCG. Using the data provided in the spreadsheet INT-INDUSTRIES-DATA.XLS, construct a discrete optimization model of the problem faced by International Industries. Solve the problem on the computer.

(b) What is the penalty for imposing restrictions (a)-(f) outlined above? That is, how much does the optimal NPV increase if these restrictions are removed?

(c) Propose a methodology to generate the second best and the third best solutions and find the second best and third best solution to your discrete optimization model.