**What is Complexity, anyway? Part 1.** September 5, 2005

## *Overview*

Complexity is, well, complex to describe. It wouldn't be complexity if it were simple now, would it? {8>)) We shall consider complexity in four installments:

1. ***Illustrative Example***
2. ***Determining the complexity of a problem/situation***
3. ***Assessing the capacity of a person to cope with complexity***
4. ***Developing your potential***

These will be in no way a complete treatment of the subject. References are included in each part to guide further study.

But you ask why should I help people understand Complexity if it is the core business value of New Global Enterprises. That is the beauty of Complexity. It is an infinite game. It takes the World Mind to understand Complexity to the fullest. And then, that is not even enough. So this is an example of limitless increasing returns that Brian Arthur, economist at the Santa Fe Institute, and others keep writing about. Understanding Complexity is the ultimate collaboration of the World Mind. There is value for all. Moreover, value is continuously available at that.

Understanding Complexity is the first step in realizing the value from it. So, without further ado, let's proceed to Installment 1.

## *Illustrative Example*

Let's take it from the top. In www.dictionary.com we find:

> **com·plex·i·ty** (kəm-plĕk'sĭ-tē)
> n : the quality of being intricate and compounded; "he enjoyed the complexity of modern computers" [syn: complexness] [ant: simplicity]

Compound intricacy, then, is the keynote. So, wrestling with and subduing complexity depends on the depth and connection of the aspects of a situation (the problem) and our ability to apprehend and manage the information necessary to sort things out.

A current puzzle craze is afoot that illustrates this point. It is Sudoku, a logic puzzle consisting usually of a 9X9 matrix of cells in which one has to arrange the numerals 1-9 so every numeral occurs once and only one in each row and column and in each of the nine 3X3 matrices within the large matrix. Barnes and Noble Bookstores display large advertising posters in their store windows for books on Sudoku. My local newspaper includes a daily 9X9 Soduko puzzle and a "monster" 16X16 one on Sundays with characters 0-9, A-F. One can make any $n^2$X$n^2$ Sudoku puzzle. The 4X4 is "too easy" and the 25X25 (using A-Y) is next to impossible to solve without manifold automated assistance. A 9X9 seems within reach of most people in less than 0.5-1.0 hour for a moderately complex puzzle.

 

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The complexity of the Sudoku puzzle problem is determined by the number of cells preset with numerals (cf., the burnt red numerals in the figure below; the dark grey numerals are the solution to the puzzle).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 6 | 3 | 1 | 7 | 4 | 2 | 5 | 8 |
| 1 | 7 | 8 | 3 | 2 | 5 | 6 | 4 | 9 |
| 2 | 5 | 4 | 6 | 8 | 9 | 7 | 3 | 1 |
| 8 | 2 | 1 | 4 | 3 | 7 | 5 | 9 | 6 |
| 4 | 9 | 6 | 8 | 5 | 2 | 3 | 1 | 7 |
| 7 | 3 | 5 | 9 | 6 | 1 | 8 | 2 | 4 |
| 5 | 8 | 9 | 7 | 1 | 3 | 4 | 6 | 2 |
| 3 | 1 | 7 | 2 | 4 | 6 | 9 | 8 | 5 |
| 6 | 4 | 2 | 5 | 9 | 8 | 1 | 7 | 3 |

(found at www.sudoku.com)

I solved this in less than 15 minutes using a little awk program (entitled "sinit.awk") I wrote to determine the initial possibilities of 1-9 in each of the unfilled cells. The helper program reduced my need to pencil in each unfilled cell initially with numerals not excluded by the rules. Here are those intermediary results which took me 15 minutes to do by hand:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 39 | 6 | 39 | 1 | 2789 | 4 | 278 | 5 | 3789 |
| 149 | 179 | 8 | 3 | 279 | 5 | 6 | 249 | 79 |
| 2 | 3579 | 3459 | 678 | 6789 | 9 | 478 | 3489 | 1 |
| 8 | 12359 | 12359 | 4 | 235 | 7 | 125 | 129 | 6 |
| 149 | 1259 | 6 | 8 | 258 | 2 | 3 | 1289 | 5789 |
| 7 | 235 | 235 | 9 | 23568 | 1 | 258 | 28 | 4 |
| 5 | 1389 | 139 | 7 | 13479 | 39 | 148 | 13468 | 2 |
| 13 | 138 | 7 | 2 | 134 | 6 | 9 | 1348 | 358 |
| 1369 | 4 | 1239 | 5 | 139 | 8 | 1 | 7 | 3 |

Results of running sinit.awk

The black numerals are consistent with applying the row, column and sub-matrix constraints. This is the first stage of a compound intricacy. Notice that this first pass processes each cell independently of applying the rules a second time. This would, for

 

example, eliminate the 9 from 2nd/3rd/5th/8th cells of the 3rd row since the 6th cell of that row contains 9. Notice the 9 can be eliminated from the 1st/2nd cells of the 5th column as well since the 9 occurs in the same sub-matrix with them. The 6th column can be completed by also eliminating the 9 from the 7th cell of that column. Note also that another application of the constraints would set the 8th cell of the 7th row to 6 since that is the only place a 6 appears possible in the row.

Note one more point on the compound intricacy (complexity) of the Sudoku puzzle in the form of derived facts from the constraint rules. One such fact is "if two cells of the same row, column or sub-matrix contain the same two numerals, then no other cell in the respective row, column or sub-matrix can contain either of those numerals." One can apply that derived rule to the 1st row of the above puzzle solution in progress and eliminate the 3 and 9 from the 9th cell of the first row and from the 1st/2nd cells of the 2nd row and from the 2nd/3rd cells of the 3rd row. This two-numeral, two-cell rule actually generalizes to an n-numeral, n-cell rule. The harder puzzles require making assumptions and following the logic path to a contradiction or a solution. This logical activity is a more intricate, compounding process than applying the constraint rules above.

This has illustrated one aspect of Complexity, albeit a simple one at that. Notice that simple appears to be hard enough. Tune in next week for Installment 2 on "Determining the complexity in a problem/situation."

 