The Zebra Puzzle

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1 Introduction

In the class textbook, the Zebra puzzle is offered as an exercise for Section 1.1 on logic (Exercise 61, page 20). Here is the puzzle:

> Five men with different nationalities and with different jobs live in consecutive houses on a street. The houses are painted different colors. The men have different pets and have different favorite drinks. Determine who owns a zebra and whose favorite drink is mineral water (which is one of the favorite drinks) given these clues[1]:
>
> 1. The Englishman lives in the red house.
> 2. The Spaniard owns a dog.
> 3. The Japanese man is a painter.
> 4. The Italian drinks tea.
> 5. The Norwegian lives in the first house on the left.
> 6. The green house is on the right of the white one.
> 7. The photographer breeds snails.
> 8. The diplomat lives in the yellow house.
> 9. Milk is drunk in the middle house.
> 10. The owner of the green house drinks coffee.
> 11. The Norwegian's house is next to the blue one.
> 12. The violinist drinks orange juice.
> 13. The fox is in a house next to that of the physician.
> 14. The horse is in a house next to that of the diplomat.

The textbook also gives the following hint:

> Make a table where the rows represent the men and columns represent the colors of their houses, their jobs, their pets, and their favorite drinks and use logical reasoning to determine the correct entries in the table.

This is a fun puzzle to think about. However, it has to do with "logic" only marginally. The real difficulty is in knowing where to start, and in how to think about the problem.

When addressing real-life problems as computer scientists, we will be in this situation often: someone poses a problem (usually less well defined than this one), and we are asked to solve it. This is different from solving a homework assignment in a class. For the homework, we are either told what technique to apply, or we can make an

[1] I have numbered the clues for later reference.

educated guess by picking a solution method from the part of the textbook that the problem refers to. In real life, all we have is the problem itself, and whatever knowledge and experience we have accumulated over time. So how do we come up with a solution? We will use the zebra puzzle to explore some heuristics for thinking about complex problems.

2 How Hard Is the Problem?

Why is it useful to know how hard the problem is? Mostly because we want to know how many resources to throw at it: Do I just scribble a couple of lines on the back of an envelope? Do I need to write a computer program? If I do, will the program run in a reasonable amount of time?

For puzzles, understanding its complexity is usually a simple exercise of combinatorics, a set of counting techniques that we will explore in this course. The web page http://mathforum.org/library/drmath/view/55627.html suggests a solution to the zebra puzzle, and starts with the following observation:

> Of course one could just enumerate the $5^5 = 3125$ different possible answers, and scratch off all of those which didn't fit the clues, but this is the hard way.

First, this may not be as hard if done with a computer program: 3000 or so alternatives can be explored in microseconds. If the program is not too complex to write, we may be done more quickly this way. An advantage of a systematic approach like this is that we can also answer ancillary questions: is the solution unique? If not, how many other solutions are there?

Another advantage of a software solution is that if the code is simple we are more confident that our solution is correct. Going through the many steps in the "logical" solution given in the web page mentioned above is error prone, and writing a short program may be safer.

Thirdly, the solution on the web page goes through a chain of arguments of which here is a snippet (that version of the problem uses flowers instead of jobs, and Ukrainians instead of Italians):

> By No.7, the geranium grower owns snails. Thus the geranium grower does not own the dog, fox, horse, or zebra, and the snail owner does not grow roses, marigolds, lilies, or gardenias. Thus the geranium owner is not the Spaniard.

We can all follow arguments of this type, given the clues. The difficulty is not in verifying whether a logical implication is valid or not. The real trouble is in coming up with a sequence of arguments that leads us to a conclusion quickly. So in a sense the given solution is not a solution unless we are also told how the solver came up with the proper sequence of arguments.

In this regard, if we can write a program that solves this puzzle, perhaps we learn how to write programs to solve other puzzles, and maybe even programs that in some sense can be said to "think."

However, the problem is harder than exploring 3000 or so alternatives. The different possible answers are not 3125, but many more. To see this, let us do what is a useful first step in all cases: let us *visualize* the problem.

Drawings always help. We could draw five little Victorian houses with windows and chimneys, paint them in five different colors, and draw a gondolier for an Italian, and so forth. Needless to say, we want something quicker. The textbook hint to use tables is good: tables organize information in a concise way, and let us view the whole situation at a glance. This is a broad view of things that is very useful to us, just as it is mostly useless to computers, which in a sense can only look at one data item at a time.

The specifics of the hint, on the other hand, are misleading. Why should we put the men on the rows, and put jobs, colors, pets, and drinks on the columns? What makes men (or their nationalities) any different, in the abstract problem, from jobs or colors? This is always a key question when you make a table: what to put on rows and columns, and should the table have two dimensions (rows, columns), or more?

Think about this for a minute. I mean it: put this document down, and actually *do* think for a while about whether the nationality of a house occupant is to be treated any differently from the job he holds, or the pet he has, for the purpose of solving the zebra puzzle.

There is really no reason for this distinction. All we have are five houses, and five "attributes" for each house: its color, the nationality, job, and favorite drink of its occupant, and the pet that lives in it. Assigning a job and an occupant to a house also automatically assigns that job to that occupant. More importantly, if we were to use the table suggested in the hint, how would we use it to express the fact that *The green house is on the right of the white one* (clue 6)? The suggested table does not say where the houses are relative to each other, while clues 5, 9, 11, 13, 14 all refer to house position.

So instead we think of five columns (not rows, merely because houses are vertical), one per house, and of five attributes that we stack in each house. One possible assignment of attributes (not consistent with the clues) is captured by Table 1. This table captures also positional information, what is where and next to what, so this type of table is more likely to help.

Color	Blue	Green	Red	White	Yellow
Nationality	Englishman	Italian	Japanese	Norwegian	Spaniard
Job	Diplomat	Painter	Photographer	Physician	Violinist
Pet	Dog	Fox	Horse	Snails	Zebra
Drink	Coffee	Milk	Orange Juice	Tea	Mineral Water
House	1	2	3	4	5

Table 1: One possible assignment of color, nationality, job, pet, and drink to the five houses.

How many such assignments can we come up with? There are five colors, so there are five possible color assignments to house 1. For each of these, there are four remaining colors that can be assigned to house 2, for a total of 4×3 combinations. For each of these, there are three colors left for house 3, two for house 4 and one for house 5. The total number of color assignments to houses is therefore $5 \times 4 \times 3 \times 2 \times 1 = 5!$ (pronounced "five factorial"), that is, 120 assignments.

Suppose that we pick one of the 120 color assignments. For this assignment, we can again choose $5!$ assignments for the nationalities of the occupants, for a total of $5! \times 5! = (5!)^2$ different combinations of colors and nationalities. If we repeat this reasoning for jobs, pets, and drinks, we see that the total number of possible assignments is $(5!)^5$, not just 5^5. That is, we have 24,883,200,000 possible assignments (that's almost 25 billion).

This rules out any exhaustive solution by hand, but not necessarily by computer: With computer clocks running in the gigahertz range, a well written program could conceivably be done in seconds or minutes.

However, this counting exercise also shows that if we had a slightly modified problem with six homes and six categories of attributes (let's add favorite flowers, for instance) instead of five, then we would have $(6!)^6$ possible assignments, which is about 1.4×10^{17}. Even if it took a single machine clock cycle to check the consistency of one assignment with the given clues, a 10GHz machine would take $1.4 \times 10^{17}/10^{10} = 1.4 \times 10^7$ seconds, that is, almost 116 days (divide seconds by $60 \times 60 \times 24$ to obtain days), to check all assignments and find one (the only one?) that is compatible with the clues.

Thus, the zebra puzzle is an example of a problem whose exhaustive solution is feasible on a single computer as given, but does not scale to any bigger problem of the same type. If we cannot come up with anything better, and if all we need to do is to solve the zebra puzzle itself, we may take this approach (and perhaps be left with an aftertaste of inelegance). If we want to gain experience with solving similar puzzles, or solve bigger ones, we need to try harder.

3 Tables and Clues

Going through the clues, we realize that some of them are more directly applicable than the others. Specifically, clues 5 and 9 let us assign the Norwegian to the first house and milk to the third. Clue 11 can also be applied right after clue 5: since the Norwegian is in the first house and he is next to a blue house, the second house is blue. After this, things become harder, as no other clue seems to be directly applicable. How do we proceed further?

We could start by drawing the compulsory assignments so far, and leave everything else blank, as in Table 2.

We could then continue adding assignments, checking for consistency with the clues as we do this. This is a natural strategy: start with what you know for sure, and grow from there. However, we would get stuck soon with this: Say that we put the Spaniard in house 2. Then we must put the dog in that house as well, because of clue 2. Then let us put the Japanese in house 3 (and the painter in house 3 because of clue 3), and the Italian in house 4 (and tea in house

	1	2	3	4	5
Color		Blue			
Nationality	Norwegian				
Job					
Pet					
Drink			Milk		
House	1	2	3	4	5

Table 2: The compulsory assignments after application of clues 5, 9, and 11.

4 because of clue 4). The Englishman can only go into house 5 (the only house without an occupant), which then is painted red (clue 1). The situation is now as in Table 3.

	1	2	3	4	5
Color		Blue			Red
Nationality	Norwegian	Spaniard	Japanese	Italian	Englishman
Job			Painter		
Pet		Dog			
Drink			Milk	Tea	
House	1	2	3	4	5

Table 3: Situation after a small number of tentative assignments.

Which house can we paint green? Since the occupant of the green house drinks coffee (clue 10), houses 3 and 4 are out of the question (their owners drink milk and tea). Houses 2 and 5 are already painted (blue and red, respectively), so the only house left is house 1. However, clue 6 says that the green house is on the right of the white one, so house 1 cannot be green, because there is no other house on its left to be painted white. We have made three assignments (Spaniard, Japanese, Italian to houses 2, 3, 4) and drawn the consequences implied by the clues, and we have literally painted ourselves into a corner. At least one of our three assignments was wrong, and we need to retract it, but which one?

We have added assignments without *prima facie* violating any clues, and we realize that something is wrong only after we have made several assignments. However, the source of our problem is not the weakness of the clues *per se*, but rather that we are not using the clues to their fullest power.

Consider for instance starting from scratch and using clues 5 and 11. The situation after this is as in Table 4. Clue

	1	2	3	4	5
Color		Blue			
Nationality	Norwegian				
Job					
Pet					
Drink					
House	1	2	3	4	5

Table 4: Situation after starting anew with the direct clues 5 and 11.

1 then states that the Englishman lives in a red house, so he cannot possibly live in house 2, which is blue. Since we can only add assignments to our table, we have no way to express this fact: We can only say where attributes are, not where they are *not*. We have information (the Englishman is not in house 2) that we cannot express in our table, so we are effectively not using it when making decisions about subsequent assignments.

To correct this situation, we could add a note "not Englishman" in the nationality box for house 2. This is OK, but is visually awkward: we cannot just scan the table quickly, because for each entry we need to check whether it has the "not" word in it: "Englishman" is very different from "not Englishman," and yet these two strings differ only little. This is not a problem for a computer, but it is for a human using visual thinking.

4 A Shrinking Table

A visually more effective table starts completely full, rather than completely empty: we first list all the assignments that are possible given the clues that we have considered so far, as shown in Table 5. We then remove assignments that are inconsistent with the clues, until we are left with a (perhaps unique) assignment for all attributes and all houses.

Color	Blue Green Red White Yellow	Blue Green Red White Yellow	Blue Green Red White Yellow	Blue Green Red White Yellow	Blue Green Red White Yellow
Nationality	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard
Job	Diplomat Painter Photographer Physician Violinist	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard
Pet	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra
Drink	Coffee Milk Orange Juice Tea Mineral Water	Coffee Milk Orange Juice Tea Mineral Water	Coffee Milk Orange Juice Tea Mineral Water	Coffee Milk Orange Juice Tea Mineral Water	Coffee Milk Orange Juice Tea Mineral Water
House	1	2	3	4	5

Table 5: A “shrinking table” initially specifies every possible choice for each assignment.

A definite assignment of a value to an attribute for a particular house (for instance, the Norwegian is in house 1) is then implemented by the following actions:

- Eliminate all other values from the list of attributes for this house (this says “this house has this value for this attribute, and no other”).
- Eliminate this value from the lists for the same attribute of other houses (this says “this value cannot be used for any other house”).

Doing this for the compulsory assignments implied by clues 5, 9, and 11 results into Table 6.

The first advantage of the new formulation with shrinking tables is that clue 6, *the green house is on the right of the white one*, can be at least partially used early on. A consequence of this rule is the negative statement that house 1 cannot be green, and this can be enforced by removing the attribute “green” from the color cell of house 1.

5 A Little Software Helps

To see what other clues can be used early on, we group all clues into three categories:

- Clues 5, 9, 11 are *direct*, in that they explicitly assign attribute values to houses.

	1	2	3	4	5
Color	Green Red White Yellow	Blue	Green Red White Yellow	Green Red White Yellow	Green Red White Yellow
Nationality	Norwegian	Englishman Italian Japanese Spaniard	Englishman Italian Japanese Spaniard	Englishman Italian Japanese Spaniard	Englishman Italian Japanese Spaniard
Job	Diplomat Painter Photographer Physician Violinist	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard	Englishman Italian Japanese Norwegian Spaniard
Pet	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra
Drink	Coffee Orange Juice Tea Mineral Water	Coffee Orange Juice Tea Mineral Water	Milk	Coffee Orange Juice Tea Mineral Water	Coffee Orange Juice Tea Mineral Water
House	1	2	3	4	5

Table 6: The shrinking table after specifying the compulsory assignments implied by clues 5, 9, and 11. Norwegian, Blue, and Milk appear alone in their cells and in their rows.

- Clues 1, 2, 3, 4, 7, 8, 10, 12 are *pair* clues, in that they all specify pairs of assignments to attributes: attribute 1 for some house has value 1 if and only if attribute 2 for some house has value 2.
- We call the remaining clues *neighborhood clues* because they involve relationships between values for attributes in different houses.

Strictly speaking, clue 11, *the Norwegian's house is next to the blue one*, is a neighborhood clue. However, it is only one step away from being direct, in that it can be applied immediately after clue 5, so for our purposes it is as good as a direct clue.

Neighborhood clues are very weak. For instance, clue 13, *the fox is in a house next to that of the physician*, only rules out combinations of assignments where there is no fox anywhere in a house unless there is a physician in a neighboring house. Since both physicians and foxes can be anywhere initially, this rule does very little in the first steps of the game. Because of analogous considerations, we use neighborhood rule 6 partially as discussed above, but we ignore the other neighborhood rules until later.

Pair clues, on the other hand, are more immediately effective. Here is where logic can help. For any given house, a pair rule can be written in the following way:

$$\text{attribute}_1 = \text{value}_1 \leftrightarrow \text{attribute}_2 = \text{value}_2$$

(the double arrow reads "if and only if""). This can be broken down into two separate statements:

$$\begin{aligned} \text{attribute}_1 = \text{value}_1 \quad &\rightarrow \quad \text{attribute}_2 = \text{value}_2 \\ \text{attribute}_2 = \text{value}_2 \quad &\rightarrow \quad \text{attribute}_1 = \text{value}_1 \end{aligned}$$

(the single arrow reads “implies that”) and also translated into two logically equivalent, *contrapositive* statements:

$$\begin{aligned} \text{attribute}_2 \neq \text{value}_2 &\quad\rightarrow\quad \text{attribute}_1 \neq \text{value}_1 \\ \text{attribute}_1 \neq \text{value}_1 &\quad\rightarrow\quad \text{attribute}_2 \neq \text{value}_2 \ . \end{aligned}$$

For concreteness, consider clue 1, *the Englishman lives in the red house*. The last four statements then become:

- If the Englishman is in a particular house, then that house is red.
- If a particular house is red, then the Englishman lives in that house.
- If a particular house is not red, then the Englishman cannot live in that house.
- If the Englishman is not in a particular house, then that house cannot be red.

We can therefore enforce this clue by examining each house in turn and act as follows:

- If the only nationality left for a house is “Englishman,” then we remove all colors other than “red” for that house.
- If the only color left for a house is “red”, then we remove all nationalities other than “Englishman” for that house.
- If a house no longer has “red” as a possible color, then we also remove “Englishman” as a possible nationality, if present, from that house.
- If a house no longer has “Englishman” as a possible nationality, then we also remove “red” as a possible color, if present, from that house.

Thus, the pair clues have only effect on attributes that have a single value, or attributes that miss a value mentioned in the clue. If a clue has no effect on a particular attribute for a particular house at a certain point in the elimination procedure, it may become relevant later on, when more values have been erased from that attribute and house. What this means is that *the pair clues need to be checked for new effects every time some values are erased from the table.*

Pragmatically, this has a very important implication: Whenever something fairly lengthy needs to be done repeatedly, it is worth considering writing a small piece of software to do it for you. Computers are great at repetition, while distractions and boredom often lead us to making mistakes.

This is exactly what I did to solve this problem. I wrote a routine that takes a table, applies all applicable pair constraints to it, and returns (and displays) the resulting table.

6 Judicious Trial and Error

Let us go back to the zebra puzzle. Using the direct clues 5, 9, 11, the neighborhood clue 6 as discussed earlier, and all the pair clues as above, results into Table 7.

After perusing Table 7 for a while, you will have to conclude that no single clue allows removing more assignments. Just as earlier, in such a case, we try a tentative assignment and see if it leads to completion, or to an impossible state of affairs (a contradiction). Since a large part of the implications of a tentative assignment are checked by software, it is easy to try different alternatives: If you save a copy of the table before making a tentative assignment, you can undo the assignment by reverting to the saved copy, should the attempt turn out to be a dead end.

The most fruitful question to ask at this stage is, which house is painted green? This is because Table 7 shows that only two houses can be green, house 4 and house 5. If we hypothesize that house 4 is green and this eventually proves to be a good choice, we are done. If on the other hand this choice turns out to lead to a contradiction, there is only one alternative (the green house is house 5), so we need to backtrack at most once.

Note that logic *per se* is not concerned with how much work we end up doing: we could equally correctly hypothesize that the fox is in house 1, and then consider the consequences of this choice, backtracking if needed. However, the fox could be in any house, so this hypothesis would be just one of five alternatives, and we would need to backtrack more often. The question is not whether we backtrack once or four times. Either way, each of our choices will in turn

House	1	2	3	4	5
Color	White Yellow	Blue	Red White Yellow	Green Red White Yellow	Green Red White Yellow
Nationality	Norwegian	Italian Japanese Spaniard	Englishman Japanese Spaniard	Englishman Italian Japanese Spaniard	Englishman Italian Japanese Spaniard
Job	Diplomat Photographer Physician Violinist	Painter Photographer Physician Violinist	Diplomat Painter Photographer Physician	Diplomat Painter Photographer Physician Violinist	Diplomat Painter Photographer Physician Violinist
Pet	Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra
Drink	Coffee Orange Juice Mineral Water	Orange Juice Tea Mineral Water	Milk	Coffee Orange Juice Tea Mineral Water	Coffee Orange Juice Tea Mineral Water

Table 7: Situation after enforcing all direct clues, clue 6, and all pair clues.

lead to situations where more choices are required, and the number of times we need to backtrack grows very rapidly if we do not make our choices wisely.

If we paint house 4 green, then clue 6 forces us to paint house 3 white. If we run again the routine that checks all pair clues, we arrive at Table 8.

Note that now yellow is forced for house 1, and this in turn requires house 5 to be the red house with the Englishman. But then the Italian must be in house 2, because the other possibility for him (house 5) is gone. Enforcing pair clues once more leads the Englishman to drink orange juice and since clue 14 requires the horse to be next to the diplomat, the horse must be in house 2. This entire chain of conclusions is forced, under the assumption that house 4 is green, and Table 9 summarizes the resulting situation.

We now need to make another tentative assignment to proceed. Again, economy compels us to make a hypothesis of where the Spaniard lives, because only two alternatives (house 3 and house 4) are possible. Equivalently, we could have worked with the painter's house (3 or 4).

Interestingly, either choice for the Spaniard's house (3 or 4) would leave either the photographer or the painter homeless after the routine check for pair clues is run: If the Spaniard is in house 3, so is his dog (clue 2), so the snails (and the photographer, clue 7) must be in house 4 (because they cannot be in house 3, the only other possibility for them). However, the Japanese painter (clue 3) also has only house 4 to go to which leaves the photographer and the painter (both of whom could have lived only in houses 3 or 4) to compete for a single home. A similar chain of inferences would ensue if the Spaniard were placed in house 4 instead of house 3.

A homeless photographer or painter is not possible. This conclusion therefore invalidates our initial assumption that house 4 is green, and the only remaining alternative must be true: house 5 is green. In logic, we would say that we have proven the theorem "House 4 is green" by contradiction: assume the contrary and derive a contradiction from this assumption (a homeless photographer or painter contradicts the fact that all men have distinct jobs and live in some house).

House	1	2	3	4	5
Color	Yellow	Blue	White	Green	Red Yellow
Nationality	Norwegian	Italian Japanese Spaniard	Japanese Spaniard	Japanese Spaniard	Englishman Italian Japanese Spaniard
Job	Diplomat	Painter Photographer Physician Violinist	Painter Photographer Physician	Painter Photographer Physician	Diplomat Painter Photographer Physician Violinist
Pet	Fox Horse Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra	Dog Fox Horse Snails Zebra
Drink	Mineral Water	Orange Juice Tea Mineral Water	Milk	Coffee	Orange Juice Tea Mineral Water

Table 8: Situation after assuming that house 4 is green, and therefore (clue 6) house 3 is white.

We can now revert to Table 7 (which our software dutifully saved for us), which was valid before we made the assumption that house 4 is green. After painting house 5 green (which we now know is certainly the case), we are led through a chain of forced inferences, assuming that every time we make a new inference we also run the automatic pair-clue check: House 4 must be white (clue 6), the Englishman must live in house 4, which is now red (clue 1), and since the horse is next to the diplomat (clue 14) it must be in house 2. Finally, pair-clue enforcement makes mineral water the only drink for the Norwegian in house 1, and we obtain Table 10.

Again, we have multiple alternatives, but we now know what to do. Let us assume that the Spaniard is in house 4 (only two alternatives). Then the Italian must be in house 2, he must be a physician (no other job left for him, after eliminating painter and violinist through clues 3 and 12), and since the fox is next to the physician (clue 13) it must be in house 1. This leaves the complete solution of Table 11.

7 Uniqueness

What would have happened, had we put the Spaniard into house 5 instead of 4? If the Italian then were to go to house 2 (could only go to either 2 or 4), then the Japanese painter (clue 3) would be forced to house 4, which would force the photographer to house 3. Since the Italian drinks tea (clue 4), the Japanese in house 4 would have to drink orange juice (the only beverage left after tea is removed for him). Because of clue 12, the violinist would go to house 4. This is a contradiction, because the Japanese occupant of house 4 is a painter (clue 3), not a violinist. The same contradiction would be reached by placing the Italian into house 4 instead of 2, so the Spaniard cannot go to house 5. The solution in Table 11 must therefore be unique, because no other alternatives remain.

Here is the answer to our puzzle: the Norwegian drinks mineral water, and the Japanese owns a zebra. Not only is this the only answer to the puzzle, but there is only one way in which all the assignments of all attribute values to all houses can be made, and houses cannot be switched with each other in any way.

	1	2	3	4	5
Color	Yellow	Blue	White	Green	Red
Nationality	Norwegian	Italian	Japanese Spaniard	Japanese Spaniard	Englishman
Job	Diplomat	Physician	Painter Photographer Physician	Painter Photographer Physician	Violinist
Pet	Fox Zebra	Horse	Dog Fox Snails Zebra	Dog Fox Snails Zebra	Fox Zebra
Drink	Mineral Water	Tea	Milk	Coffee	Orange Juice
House	1	2	3	4	5

Table 9: Result of a chain of forced inferences starting from Table 8. From here, both hypotheses for the house (3 or 4) of the Spaniard will leave the photographer and the Japanese painter fighting for a home.

In summary, a proper choice of problem formulation (the "shrinking table") together with a few lines of code and a judicious choice of tentative assignments has given us a solution systematically, and with a proof of uniqueness. This is the same result we would have obtained by trying all 25 billion possible answers, but with much less work by both man and machine, and in a way that promises to scale quite immediately to larger problems (something we cannot say for the brute-force solution), and possibly to similar but different puzzles or even real-life problems.

	1	2	3	4	5
Color	Yellow	Blue	Red	White	Green
Nationality	Norwegian	Italian Japanese	Englishman	Italian Japanese Spaniard	Japanese Spaniard
Job	Diplomat	Painter Physician Violinist	Photographer Physician	Painter Photographer Physician Violinist	Painter Photographer Physician
Pet	Fox Zebra	Horse	Fox Snails Zebra	Dog Fox Snails Zebra	Dog Fox Snails Zebra
Drink	Mineral Water	Orange Juice Tea	Milk	Orange Juice Tea	Coffee
House	1	2	3	4	5

Table 10: Result of forced inferences after painting house 5 green.

	1	2	3	4	5
Color	Yellow	Blue	Red	White	Green
Nationality	Norwegian	Italian	Englishman	Spaniard	Japanese
Job	Diplomat	Physician	Photographer	Violinist	Painter
Pet	Fox	Horse	Snails	Dog	Zebra
Drink	Mineral Water	Tea	Milk	Orange Juice	Coffee
House	1	2	3	4	5

Table 11: The final, unique assignment.