Ripple Effect

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Sudoku, today's most well-known grid-solving puzzle, was originally invented by Howard Garns in 1978. NIKOLI Co., Ltd., a magazine publisher, introduced the puzzle in Japan during the 1980s. Almost 30 years later, its popularity suddenly exploded. Bookstores now carry dozens of Sudoku books.

Eventually, other puzzle types will explode in popularity. This new column presents obscure logic puzzles of various sorts and challenges the readers to solve the puzzles in two ways: by hand and with *Mathematica.* For the latter, solvers are invited to send their code to edp@wolfram.com. The person submitting the most elegant solution will receive a prize.
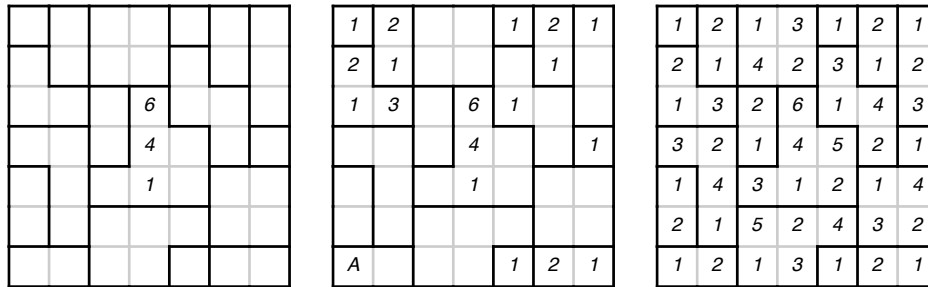
■ Instructions

Ripple Effect was first published in *Puzzle Communication Nikoli* in May 1998 [1]. In these puzzles, a grid is divided into polyomino-shaped rooms.

1. Each room contains consecutive numbers starting from 1. Thus, a domino will always have 1 and 2. A triomino will always have 1, 2, and 3. And so on.

2. If a number is duplicated in a row or a column, the space between the duplicated numbers must be equal to or larger than the value of the number. Thus, there will always be at least one digit between 1s, at least two digits between 2s, and so on.

Here is a solved example puzzle. The first grid is the puzzle itself. In the second, some preliminary logic has been done. To start, all single squares need a 1. Ones cannot be adjacent, which forces a few more placements. The square marked "A" cannot be a 2, since the domino above it could not be filled. With further logic, the entire puzzle is solved.
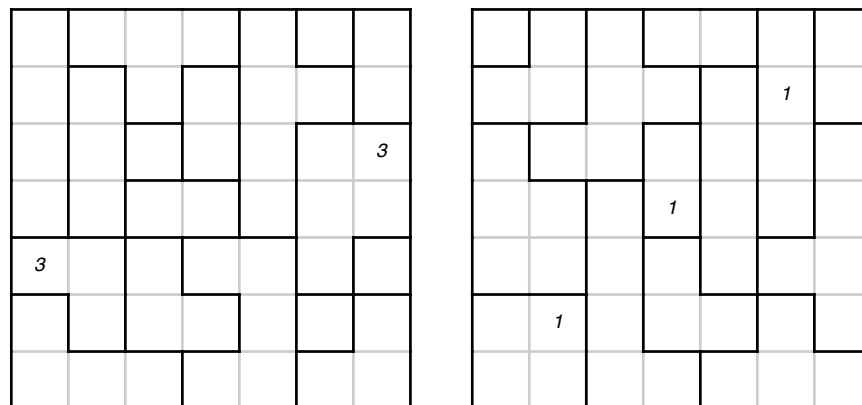
■ Example

```
Show[GraphicsArray[
  Map[Graphics[Riplines[#], AspectRatio → Automatic] &,
    {RippleEffectPuz01, RippleEffectPuz01a,
     RippleEffectPuz01b}] /. 9 → "A"]]
```

First grid (RippleEffectPuz01):

			6			
			4			
			1			

Second grid (RippleEffectPuz01a):

1	2			1	2	1
2	1					1
1	3		6	1		
			4			1
			1			
A				1	2	1

Third grid (RippleEffectPuz01b):

| 1 | 2 | 1 | 3 | 1 | 2 | 1 |
2	1	4	2	3	1	2
1	3	2	6	1	4	3
3	2	1	4	5	2	1
1	4	3	1	2	1	4
2	1	5	2	4	3	2
1	2	1	3	1	2	1

■ Puzzles

Here are two warm-up puzzles to solve, both from the *Puzzle Cyclopedia* [2]. See the Puzzle Source section for the puzzle entry code and the Code section for the graphics.

```
Show[GraphicsArray[
  Map[Graphics[Riplines[#], AspectRatio → Automatic] &,
   {RippleEffectPuz02, RippleEffectPuz03}]]]
```
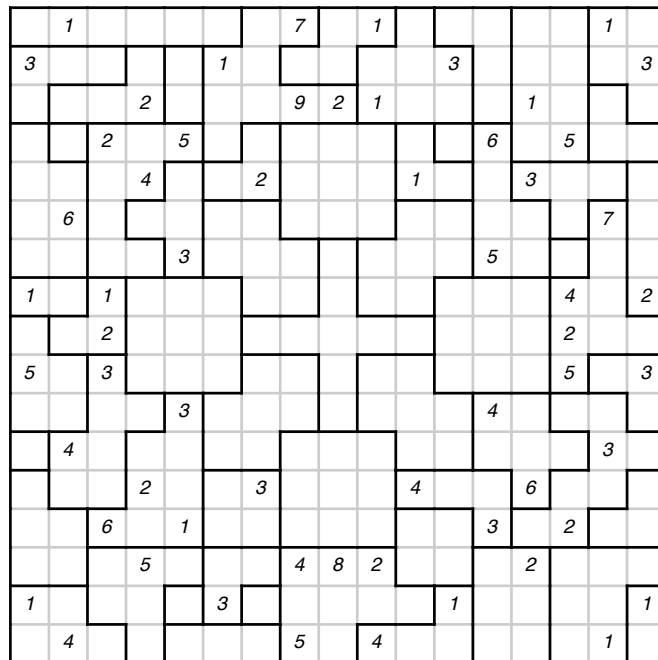
RippleEffectPuz02:

					3	
3						

RippleEffectPuz03:

				1		
		1				
	1					

Here are some intermediate puzzles from *Puzzle Communication Nikoli* [3].

```
Show[GraphicsArray[
  Map[Graphics[Riplines[#], AspectRatio → Automatic] &,
   {RippleEffectPuz04, RippleEffectPuz05,
    RippleEffectPuz06}]]]
```
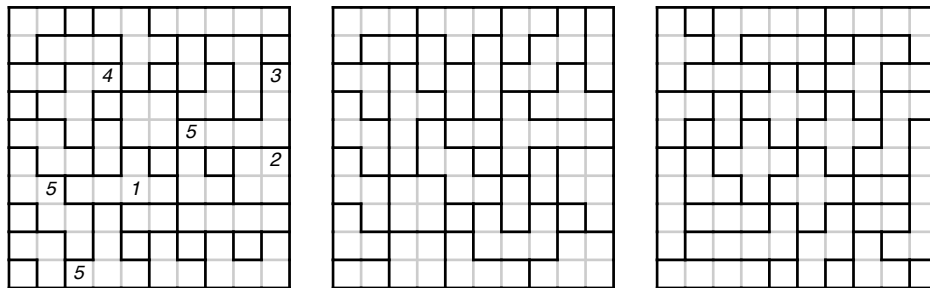
Finally, here is a challenge puzzle from *Puzzle Communication Nikoli* [3].

```
Show[Graphics[Riplines[RippleEffectPuz07],
  AspectRatio → Automatic]]
```

Do let us know what you think of this new column. Send your comments to edp@wolfram.com.

■ Puzzle Source

```
RippleEffectPuz01 =
  {{7, 7}, {4454, 8518, 10 370, 5281, 1711, 1039, 10 277},
   {0, 0, 6000, 4000, 1000, 0, 0}};


RippleEffectPuz01a =
  {{7, 7}, {4454, 8518, 10 370, 5281, 1711, 1039, 10 277},
   {1 200 121, 2 100 010, 1 306 100, 4001, 1000, 0, 9 000 121}};


RippleEffectPuz01b =
  {{7, 7}, {4454, 8518, 10 370, 5281, 1711, 1039, 10 277},
   {1 213 121, 2 142 312, 1 326 143, 3 214 521, 1 431 214,
    2 152 432, 1 213 121}};


RippleEffectPuz02 =
  {{7, 7}, {9569, 8489, 8736, 8544, 5361, 9268, 10 992},
   {0, 0, 3, 0, 3 000 000, 0, 0}};


RippleEffectPuz03 =
  {{7, 7}, {1105, 5153, 8291, 11 107, 11 055, 775, 981},
   {0, 10, 0, 1000, 0, 100 000, 0}};


RippleEffectPuz04 =
  {{10, 10}, {332 800, 435 607, 984 244, 269 044, 670 208,
    438 746, 327 930, 615 680, 27 801, 305 173},
   {0, 0, 4 000 003, 0, 5000, 2, 500 100 000, 0, 0, 50 000 000}};


RippleEffectPuz05 =
  {{10, 10}, {5384, 177 960, 342 948, 592 661, 664 832,
    142 117, 23 141, 547 917, 656 394, 329 066},
   {0, 0, 0, 0, 0, 0, 0, 0, 0, 0}};


RippleEffectPuz06 =
  {{10, 10}, {589 994, 666 178, 610 565, 32 842, 102 747,
    742 507, 774 167, 525 443, 611 999, 3606},
   {0, 0, 0, 0, 0, 0, 0, 0, 0, 0}};
```

```
RippleEffectPuz07 =
  {{17, 17}, {5 727 850 576, 11 335 128 144, 8 651 428 956,
    2 511 352 415, 384 843 266, 441 456 262, 374 822 582,
    5 907 107 862, 2 688 544 789, 269 963 280, 374 822 588,
    10 105 820 847, 1 526 366 396, 721 065 200, 353 359 509,
    11 125 387 926, 11 386 421 910},
   {1 000 007 010 000 010, 30 000 100 000 300 003,
    20 009 210 001 000, 205 000 000 060 500, 40 020 001 003 000,
    6 000 000 000 000 070, 3 000 000 050 000, 10 100 000 000 000 402,
    00 200 000 000 000 200, 50 300 000 000 000 503,
    3 000 000 040 000, 4 000 000 000 000 030, 20 030 004 006 000,
    601 000 000 030 200, 50 004 820 002 000, 10 000 300 000 100 001,
    4 000 005 040 000 010}};
```

■ Code

```
Riplines[Rip_List] := {GrayLevel[.8],
  Table[Line[{{n, 0}, {n, Rip[[1, 2]]}}],
   {n, 1, Rip[[1, 1]]}],
  Table[Line[{{0, m}, {Rip[[1, 1]], m}}],
   {m, 1, Rip[[1, 2]]}], GrayLevel[0],
  DeleteCases[{With[{A = Reverse[PadLeft[Map[
          IntegerDigits[#, 4, Rip[[1, 1]]] &, Rip[[2]]],
        Rip[[1]] + 2, 5, 1]]},
    Table[{
      If[A[[m, n]] ≠ A[[m, n + 1]],
       Line[{{n, m - 1}, {n, m}} - 1] ],
      If[A[[m, n]] ≠ A[[m + 1, n]],
       Line[{{n, m}, {n - 1, m}} - 1] ]},
     {m, 1, Rip[[1, 1]] + 1}, {n, 1, Rip[[1, 2]] + 1}]],
    With[
     {A = Reverse[Map[IntegerDigits[#, 10, Rip[[1, 1]]] &,
         Rip[[3]]]]},
     Table[If[A[[m, n]] ≠ 0,
       Text[A[[m, n]], {n, m} - {.5, .5}]],
      {n, 1, Rip[[1, 1]]}, {m, 1, Rip[[1, 2]]}]]}, Null, 4]}
```

■ References

[1] *Puzzle Communication Nikoli*, **73**, ISBN 4890724060, Tokyo, Japan: NIKOLI Co., Ltd., May 1998. www.nikoli.co.jp/howtoget-e.htm.

[2] *Puzzle Cyclopedia*, ISBN 489072060, Tokyo, Japan: NIKOLI Co., Ltd., 2004. www.nikoli.co.jp/howtoget-e.htm.

[3] *Puzzle Communication Nikoli*, **107**, ISBN 4890726071, Tokyo, Japan: NIKOLI Co., Ltd., Summer Issue. www.nikoli.co.jp/howtoget-e.htm.

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