Maze Program

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displaying a maze

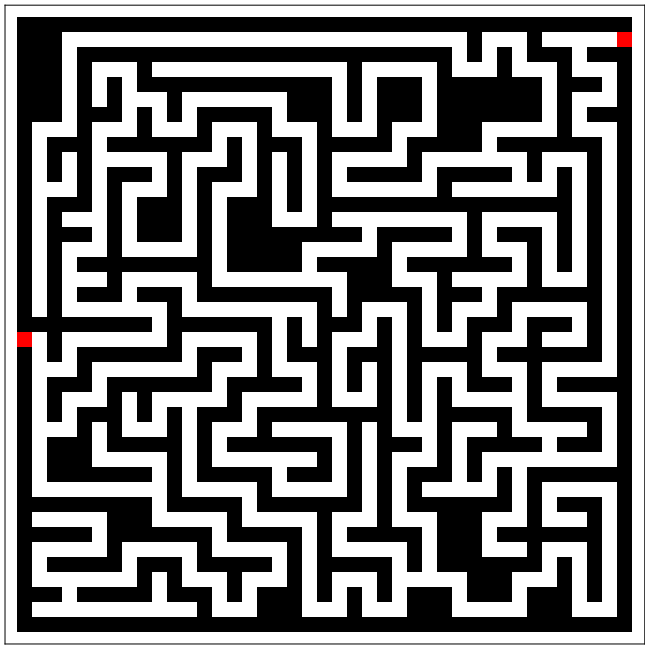
In[13]:=
```
showMaze[board_] :=
 ArrayPlot[Reverse[board], ColorRules → {e → Red, 1 → Black, 0 → White}]
```

迷路例

In[14]:=
```
maze = {{1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
   1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1},
  {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1,
   1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1}, {1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0,
   1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 0, 1},
  {1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0,
   0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1}, {1, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1,
   1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1},
  {1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0,
   1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1}, {1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0,
   1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1},
  {1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
   1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1}, {1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1,
   1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1},
  {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0,
   0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1}, {1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1,
   1, 1, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1},
  {1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0,
   1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1}, {1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1,
   1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1},
  {1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0,
   1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1}, {1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0,
   1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1},
  {1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0,
   0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1}, {1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
   1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1},
  {e, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0,
   0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1}, {1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1,
   1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 0, 1},
  {1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0,
   1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1}, {1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1,
   1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1},
  {1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0,
   1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1}, {1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0,
   1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1},
  {1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0,
   0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1}, {1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0,
   1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1},
  {1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0,
   1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1}, {1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1,
   1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1},
  {1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0,
   0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1}, {1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1,
   1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1},
  {1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
   1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1}, {1, 1, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1,
   1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1},
  {1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0,
   1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 0, 0, 1}, {1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1,
   1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1},
  {1, 1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
   1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1}, {1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
   1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1},
  {1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
   0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, e}, {1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
   1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1}};
```

In[15]:=
```
showMaze[maze]
```

Out[15]=

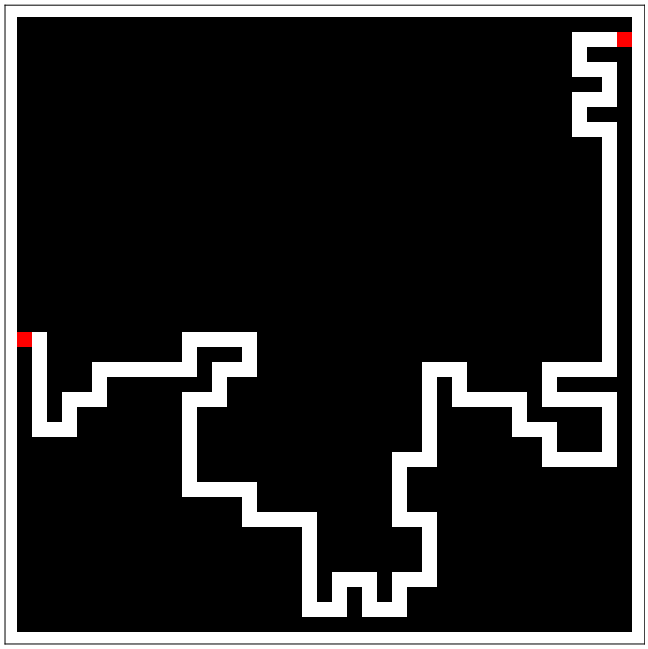


serial version

In[16]:=
```
findPathOfMaze[board_] := Module[{mazeSolve, vnNeighbors0},
  (* the following update rules can be replaced with CellularAutomaton[] *)
  mazeSolve[0, 1, 1, 1, 0] := 1;
  mazeSolve[0, 1, 1, 0, 1] := 1;
  mazeSolve[0, 1, 0, 1, 1] := 1;
  mazeSolve[0, 0, 1, 1, 1] := 1;
  mazeSolve[0, 1, 1, 1, 1] := 1;
  mazeSolve[x_, _, _, _, _] := x;
  Attributes[mazeSolve] = Listable;
  vnNeighbors0[maze_] :=
   Map[RotateRight[maze, #] &, {{0, 0}, {0, 1}, {1, 0}, {0, -1}, {-1, 0}}];
  updateMaze[maze_] := mazeSolve @@ vnNeighbors0[maze];
  FixedPoint[updateMaze, board]
 ]
```

In[17]:=
```
findPathOfMaze[maze] // showMaze
```

Out[17]=



parallel version

The following program is relatively NOT faster than the serial version because problem size is relatively small and the comuunication overhead is large.

This program demonstrates that parallel-CA approach can be easily applied to with MPI proramming.

In[18]:=
```
padding[mat_] := Module[{m}, m = Table[0, {Length[mat] + 2}, {Length[mat〚1〛]}];
    m〚2 ;; -2〛 = mat;
    m];
```

In[19]:=
```
peal[mat_] := Module[{m, n},
    {m, n} = Dimensions[mat];
    mat〚2 ;; m - 1〛];
```

In[20]:=
```
parallelFindPathOfMaze[board_, n_] := Module[{mazeSolve, vnNeighbors0, mat},
  mazeSolve[0, 1, 1, 1, 0] := 1;
  mazeSolve[0, 1, 1, 0, 1] := 1;
  mazeSolve[0, 1, 0, 1, 1] := 1;
  mazeSolve[0, 0, 1, 1, 1] := 1;
  mazeSolve[0, 1, 1, 1, 1] := 1;
  mazeSolve[x_, _, _, _, _] := x;
  Attributes[mazeSolve] = Listable;
  vnNeighbors0[maze_] :=
   Map[RotateRight[maze, #] &, {{0, 0}, {0, 1}, {1, 0}, {0, -1}, {-1, 0}}];
  updateMaze[maze_] := mazeSolve @@ vnNeighbors0[maze];

  (* note: FixedPoint is not used because of making the algorithm be simpler *)
  mpiScatter[board, mat, 0, mpiCommWorld];
  mat = padding[mat];
  Nest[Function[{a}, EdgeCell[mat]; mat = updateMaze[mat]], mat, n];
  Flatten[peal /@ mpiGather[mat], 1]
 ]
```

In[21]:=
```
parallelFindPathOfMaze[maze, 218] // showMaze
```

Out[21]=