Introduction

Basics of Programming 1

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Contents

Chapter 1

Introduction

Contact

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- BME Faculty of Electrical Engineering and Informatics
  - Department of Networked Systems and Services
- Gábor Horváth
  - email: horvath.gabor@vik.bme.hu
- Important webpages for the course:
  - The main webpage (slides, exercises, solutions): `http://www.hit.bme.hu/~ghorvath/bop/`
  - The portal managing the assignments: `https://cprog.eet.bme.hu`

Requirements

1. Laboratory practices
   - Active participation on at least 70% of the labs
   - Entrance test at the beginning of the labs
   - Max. number of absences/falied entrance tests: 4
   - Solutions to lab problems must be uploaded to CProg
2. Classroom practices
   - Participation on at least 70% of the practices
   - 6 mid-term "small tests" in total (10 pts each)
   - The sum of best 4 must be above 20 pts
   - No re-take available
3. "Big test"
   - There will be 2 mid-term "big tests": week 7 and week 14
   - Option 1: sum of the scores $\geq 50\%$
   - Option 2: the score of the second one $\geq 50\%$
   - The one with lower score can be re-taken
4. Homework project
   - Milestones will be published, extra score if deadlines are met
   - Face-to-face presentation in mandatory

Recommended literature

Any book about Standard C programming language
in your own language

Chapter 2

Basic terms

Programming

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Programming

How to make ham and eggs?

Programming

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2 Add three eggs to it
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Programming

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How to bring the oil to boiling?

```
1 Light the fire
2 Wait a little bit
3 Is the oil hot enough?
4 If not, go back to line 2
```

The impreative programming paradigm

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The impreative programming paradigm

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Programming

We tell the computer what to do

The impreative programming paradigm

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Programming paradigms

These are the principles, that we use to create the program

- Imperative programming
- Functional programming
- Object-oriented programming
- etc. . .

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The impreative programming paradigm

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Programming

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Programming paradigms

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Imperative programming

We tell the computer step-by-step, what to do

- by defining an algorithm

The process of programming

We will always take these steps during the course:

1. We describe the task
2. We construct an algorithm for solving the task
3. We create the program – we create the code of the algorithm

The process of programming

In more details:

1. We describe the task
2. We give an exact specification of the task
3. We select the right data structure for modelling the problem
4. We construct an algorithm for solving the task
5. We select an effective programming language for coding (in this course: C)
6. We create the code of the algorithm (coding)
7. We test the program

Algorithm

Algorithm (method)

A finite sequence of steps, that can be performed mechanically and leads to the solution

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- Before coding we check if the algorithm
  - right – it gives solution to our problem (and not to something else)
  - complete – it gives solution in all possible cases
  - finite – it will end in finite number of steps
- It is not enough to try, you also have to prove it!

Algorithms – examples

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Algorithms – examples

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Algorithms – examples

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  3. $n = 64, \quad n/4 = 16, \quad 16 \cdot 16 = 256 \neq 64$
- The algorithm is not complete

Algorithms

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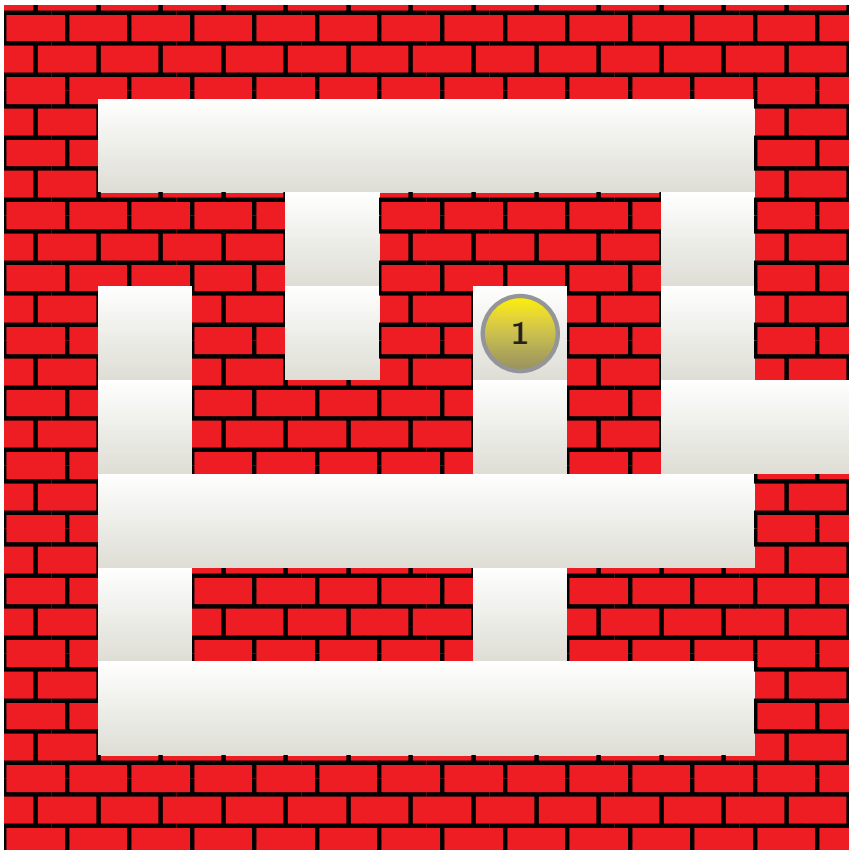
- Task: Escape from the dark maze (labyrinth)



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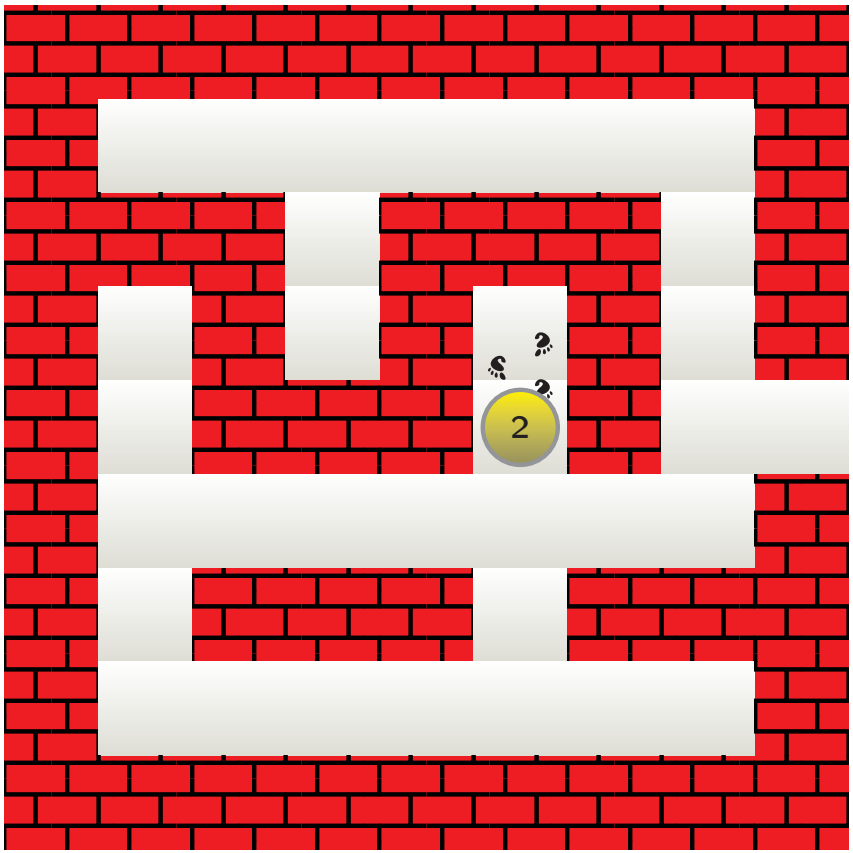

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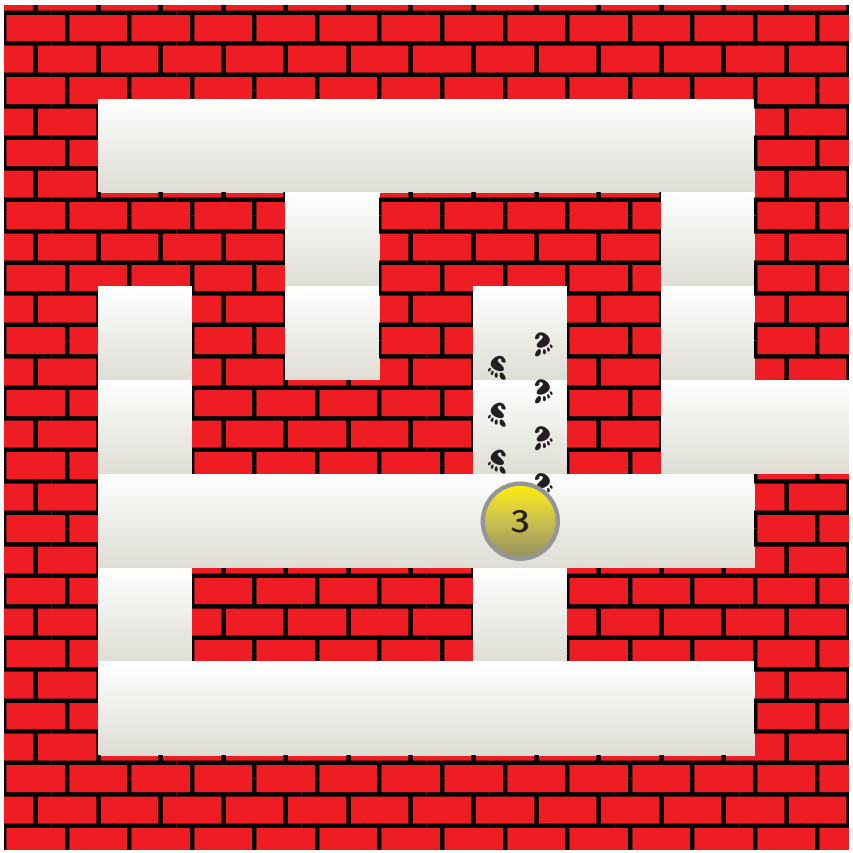

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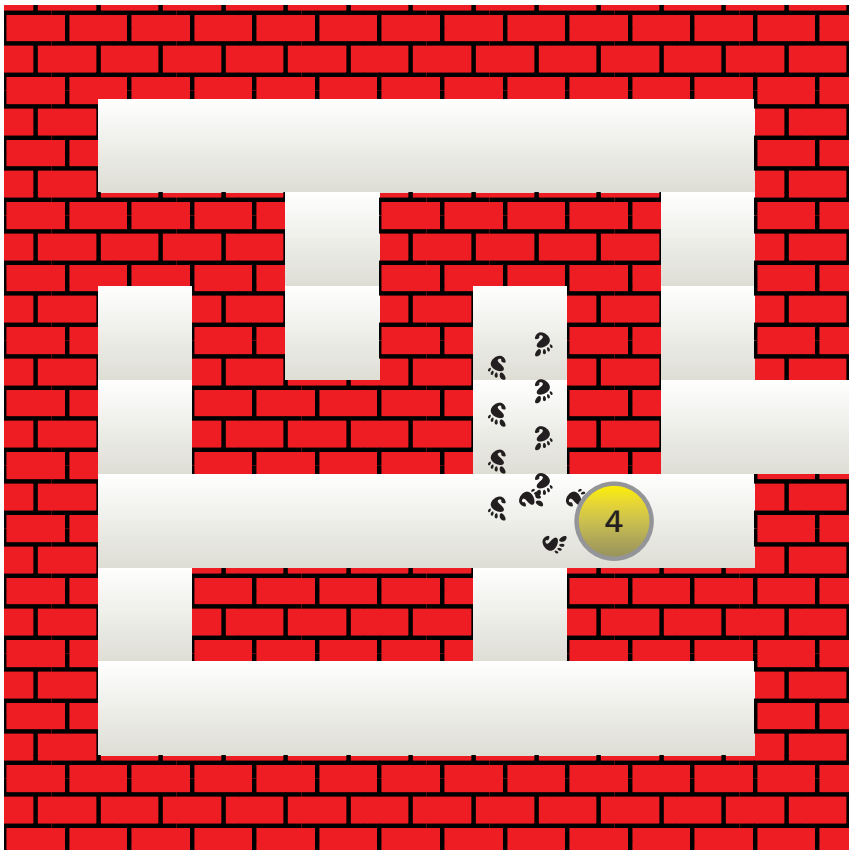

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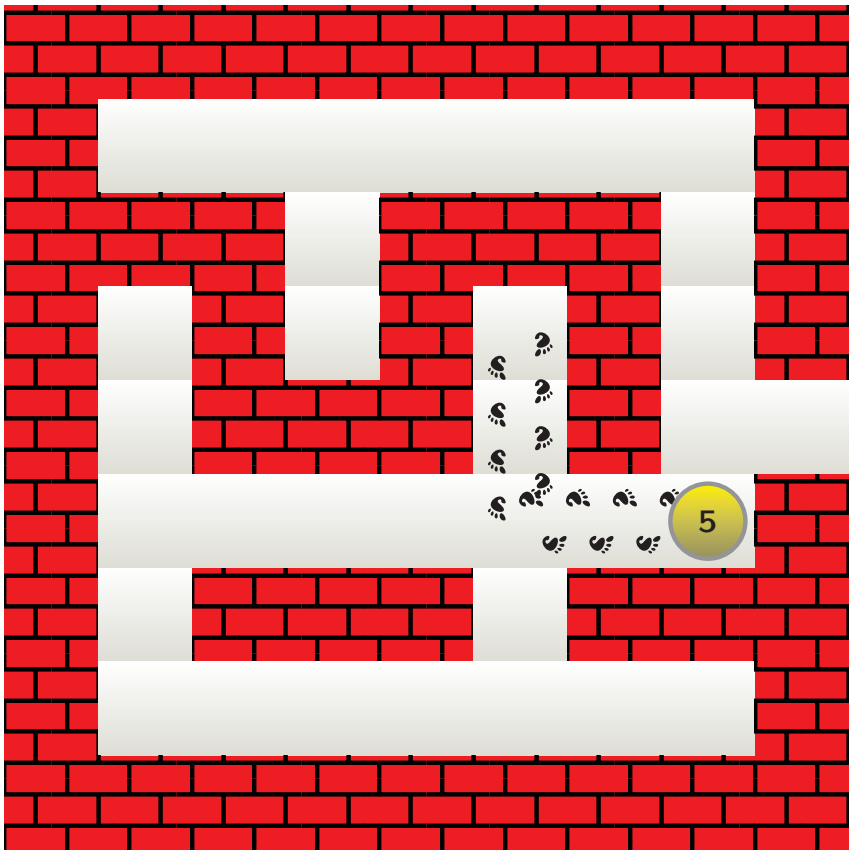

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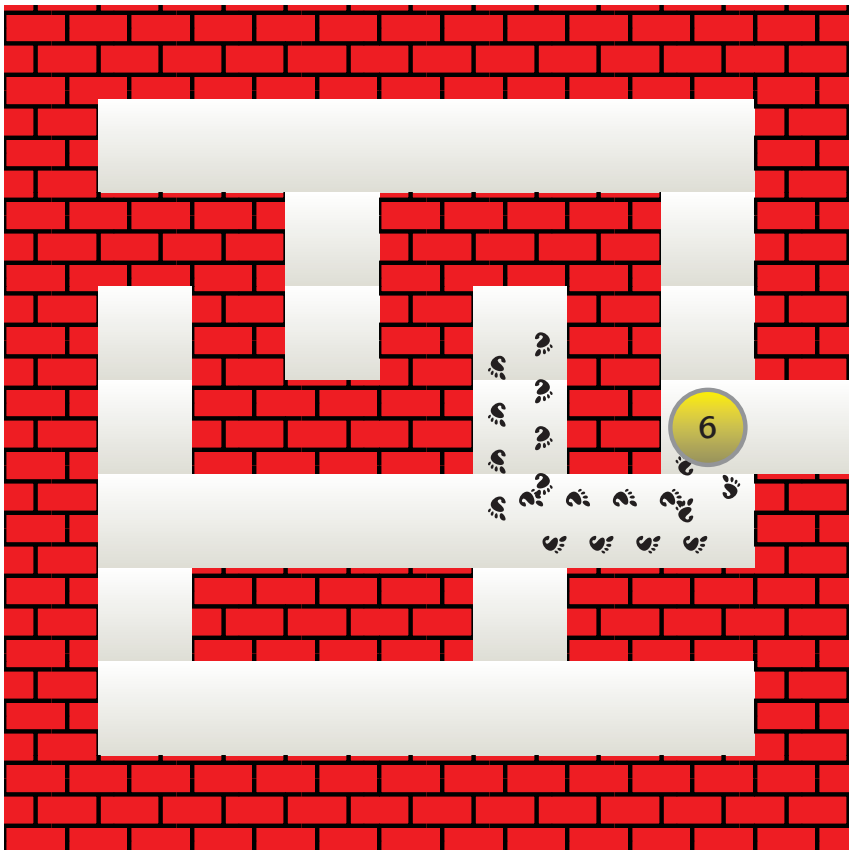

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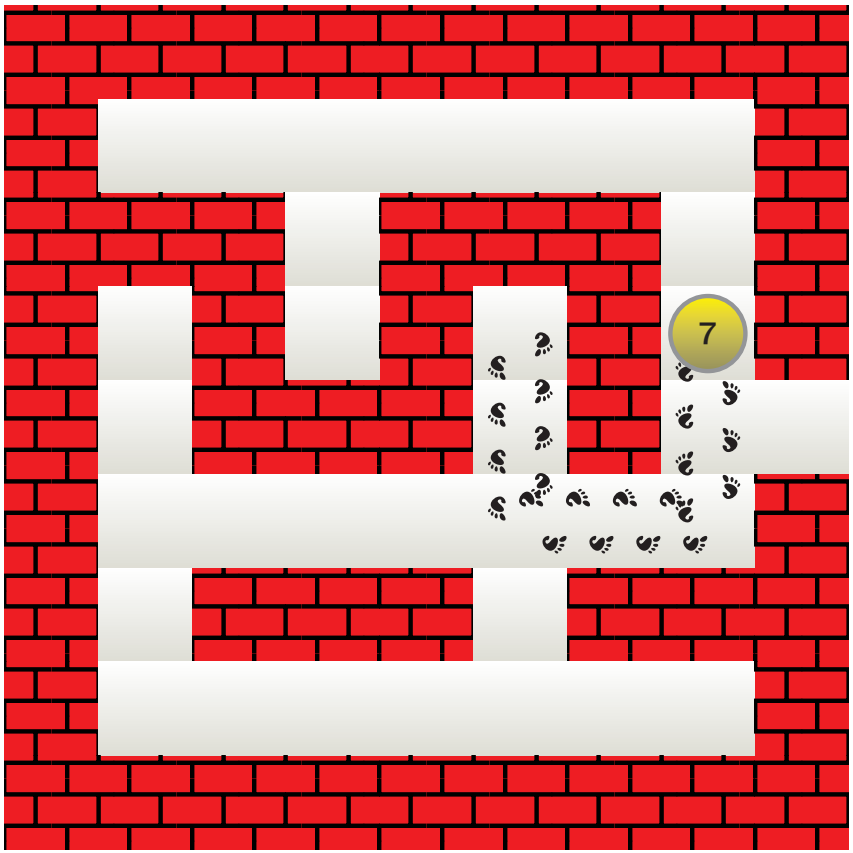

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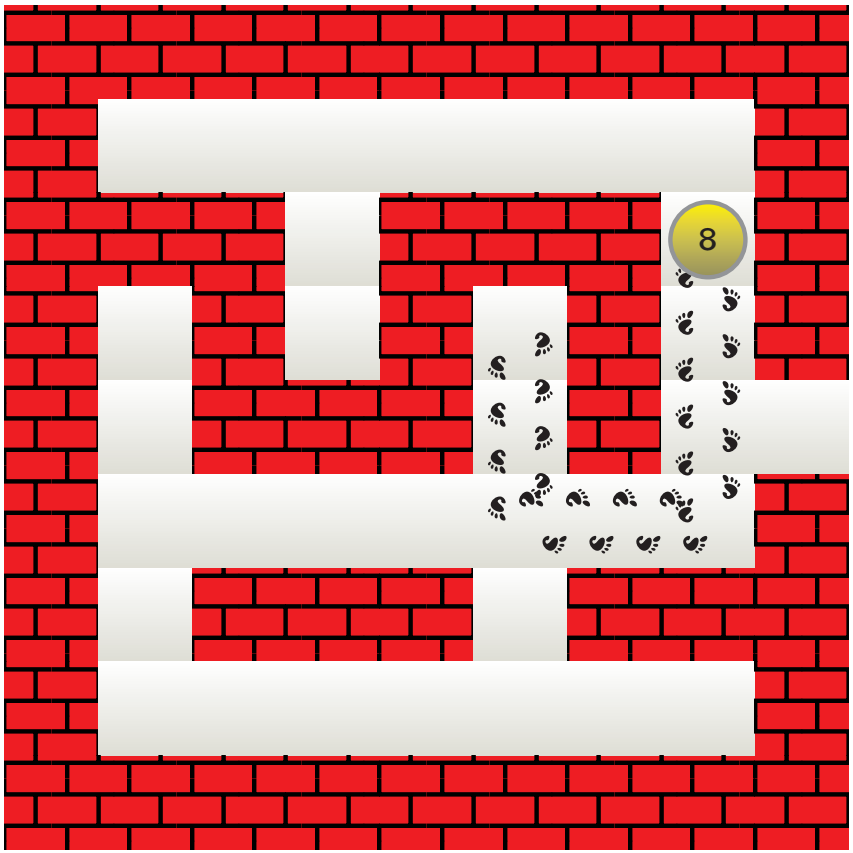

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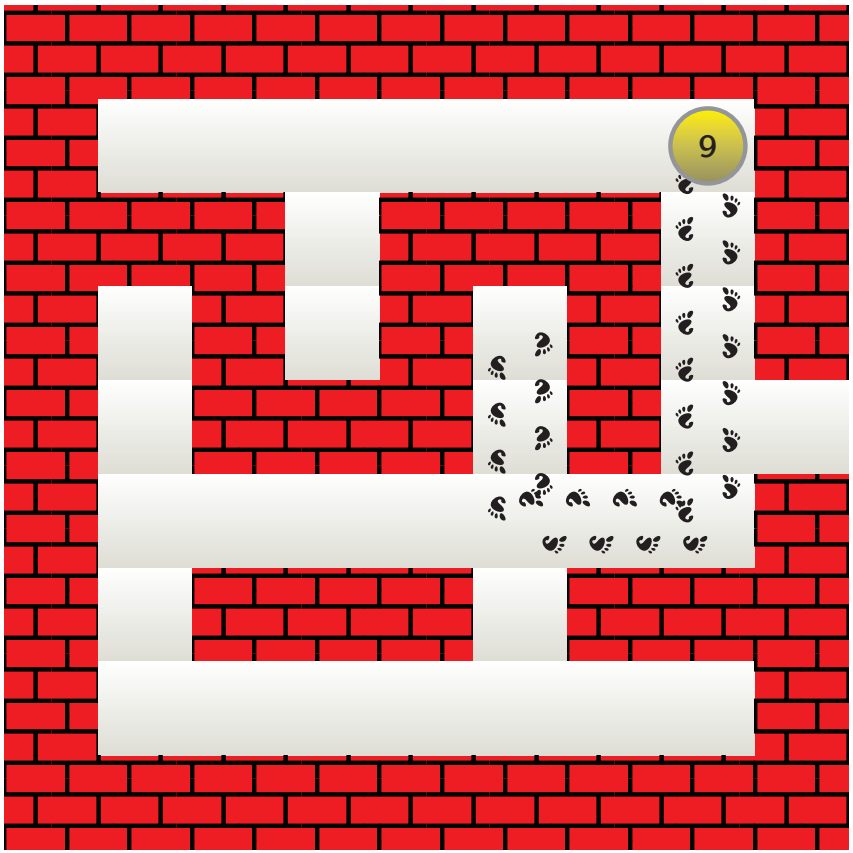

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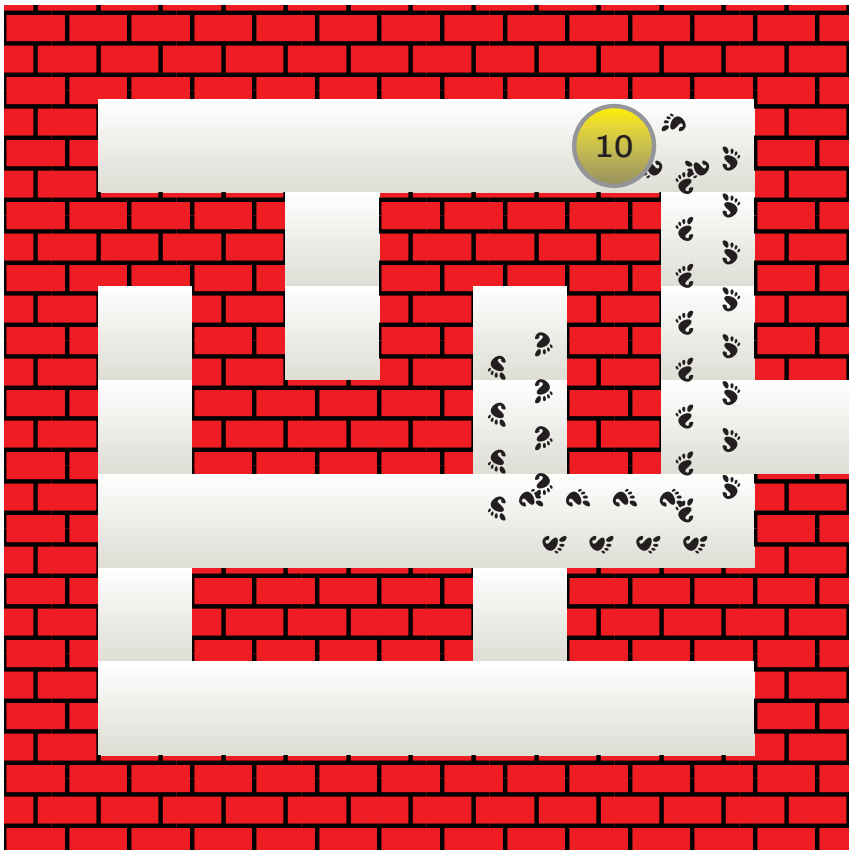

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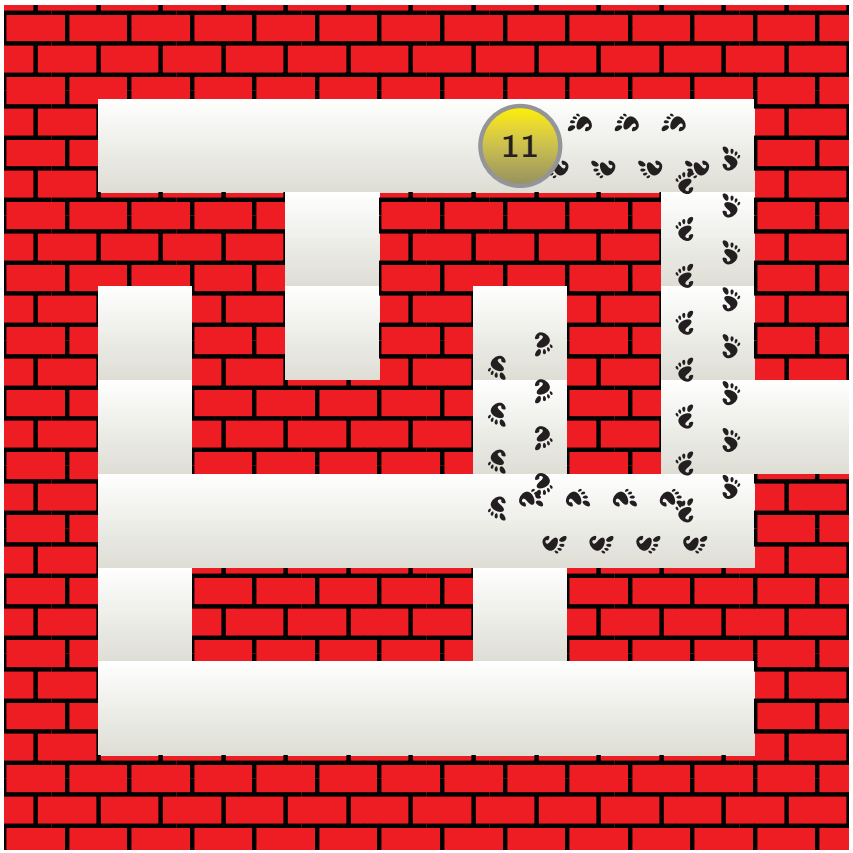

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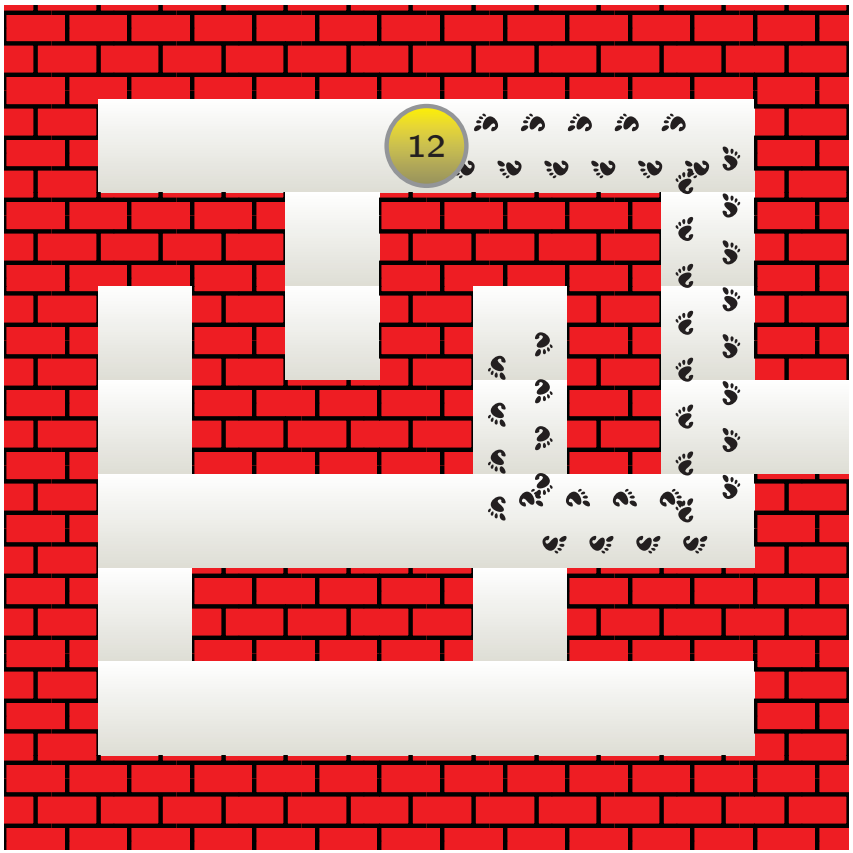

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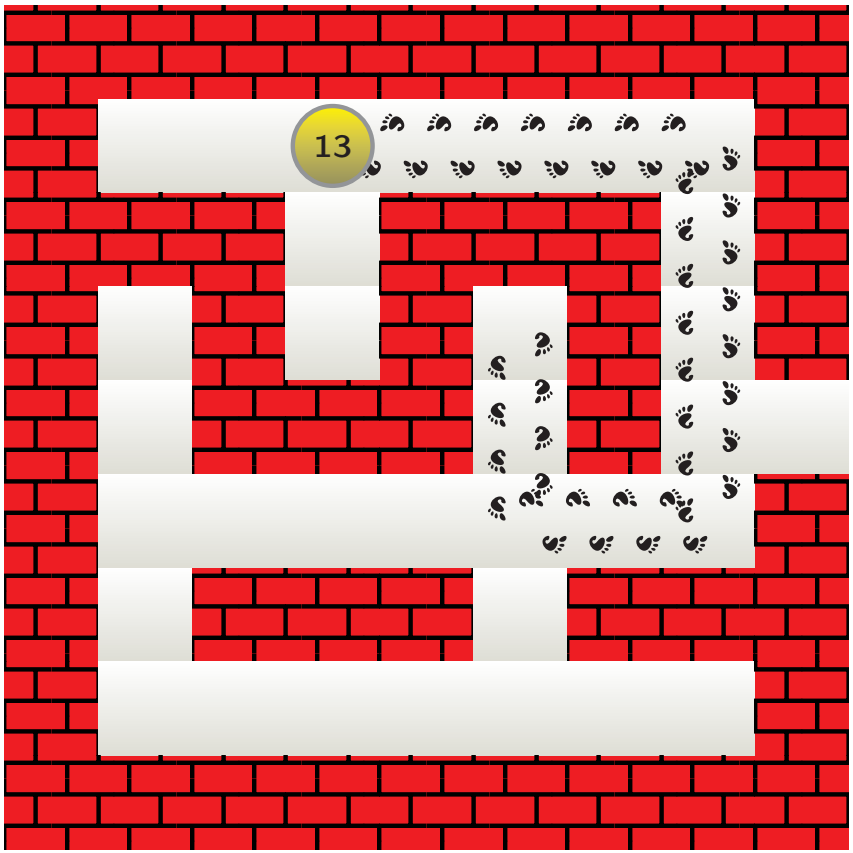

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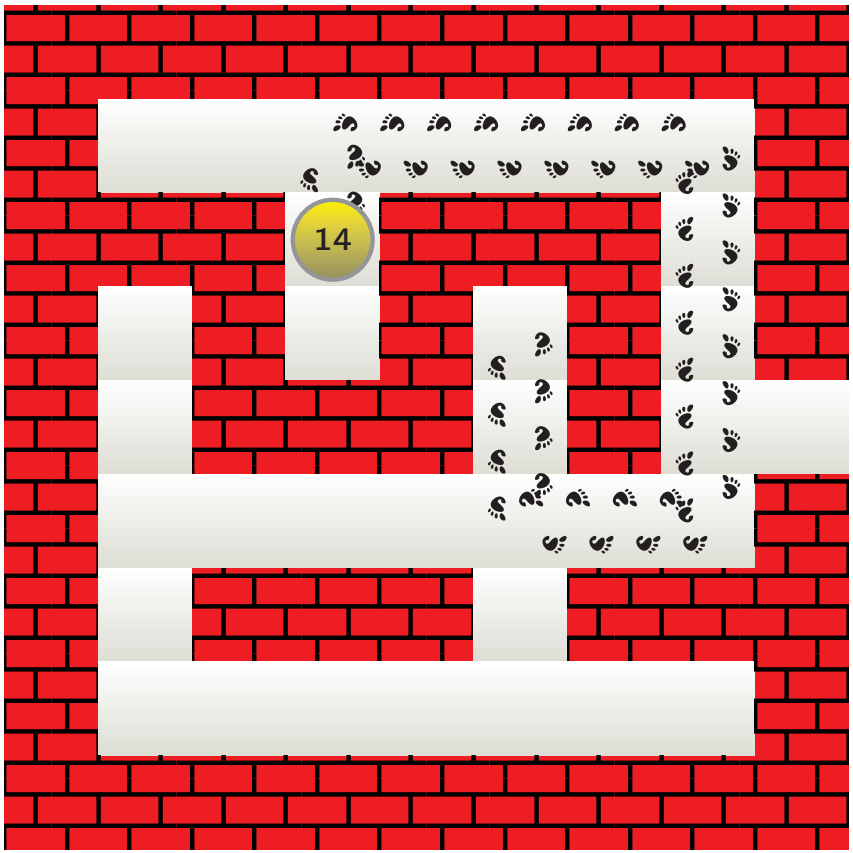

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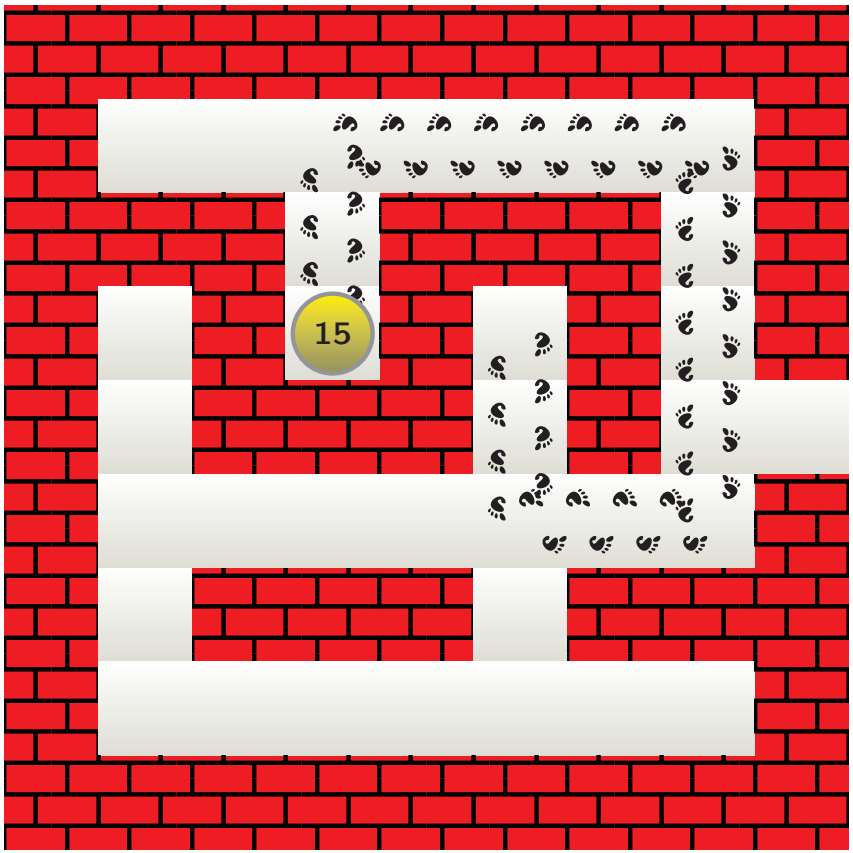

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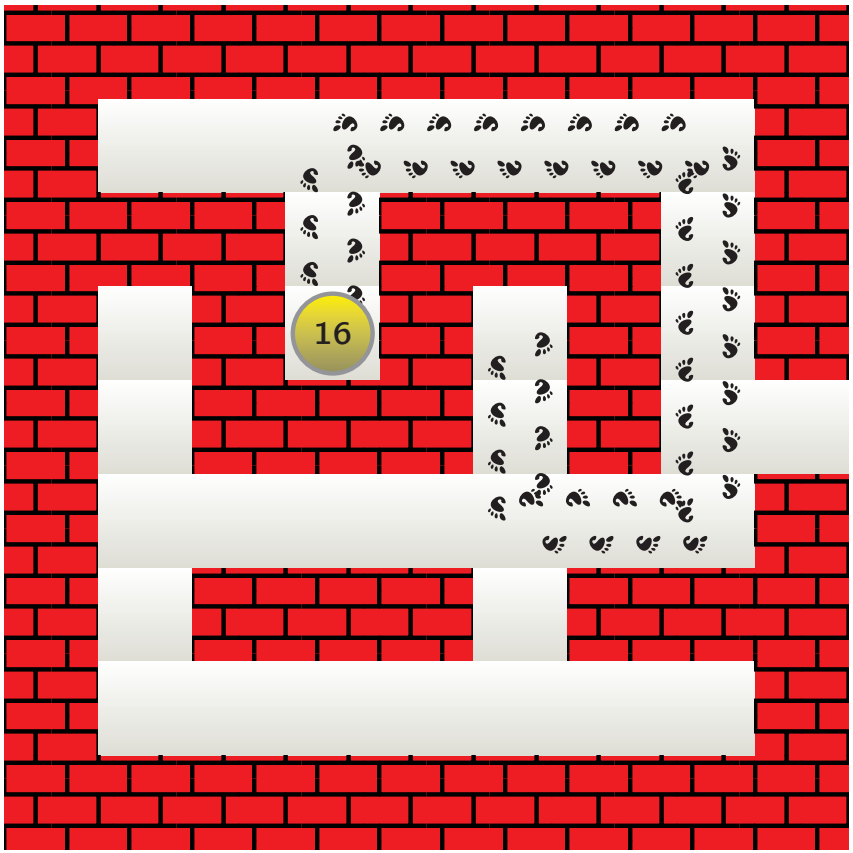

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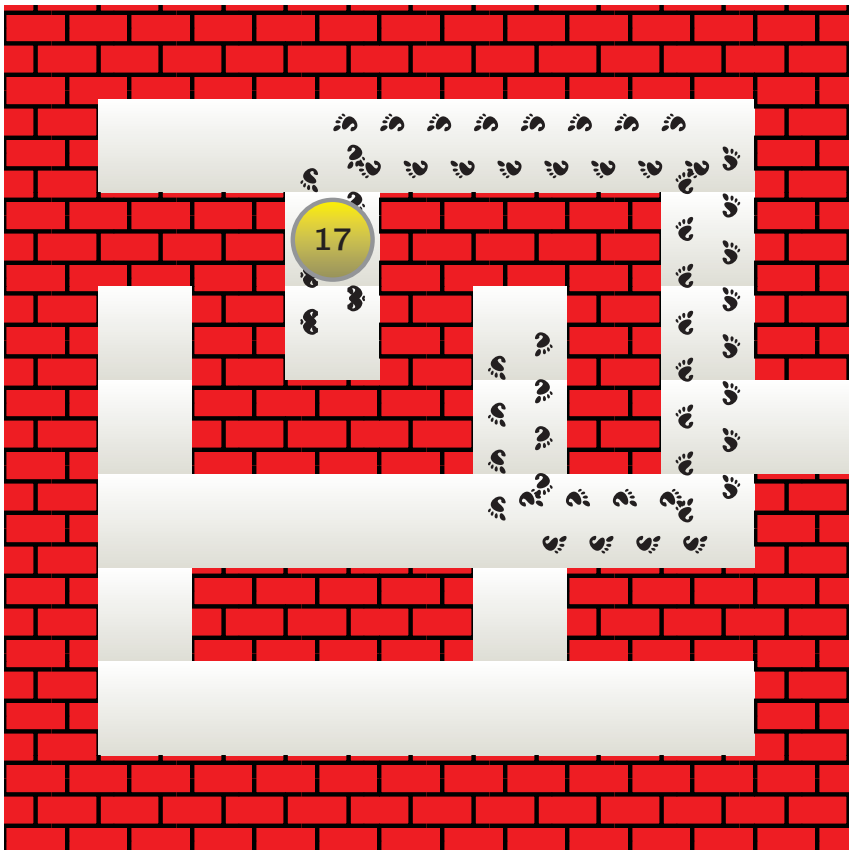

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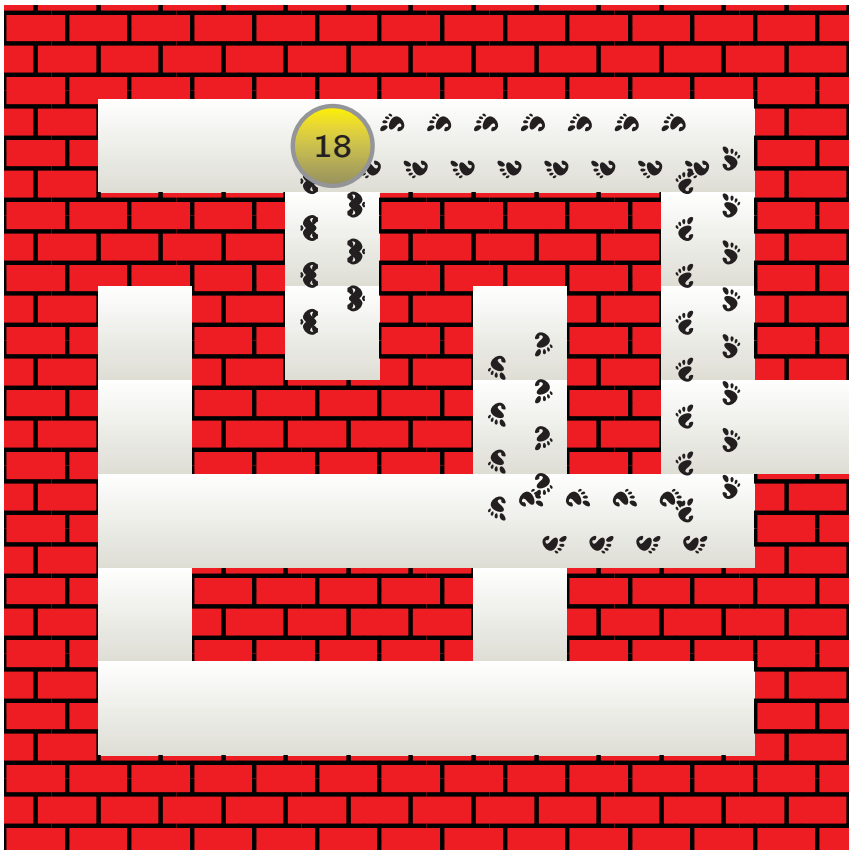

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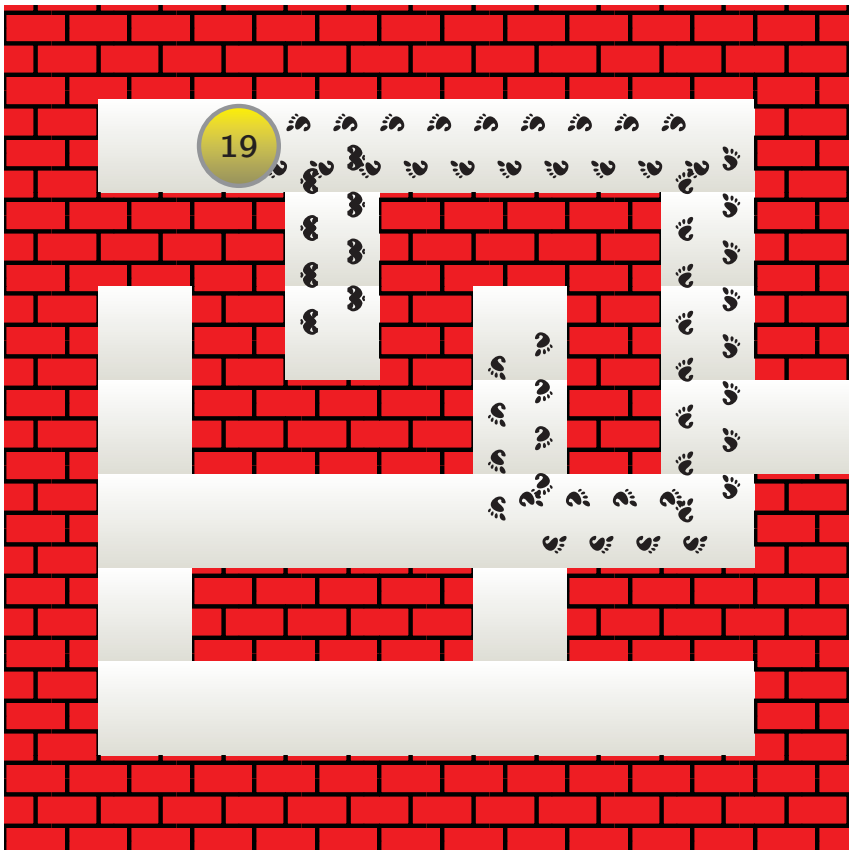

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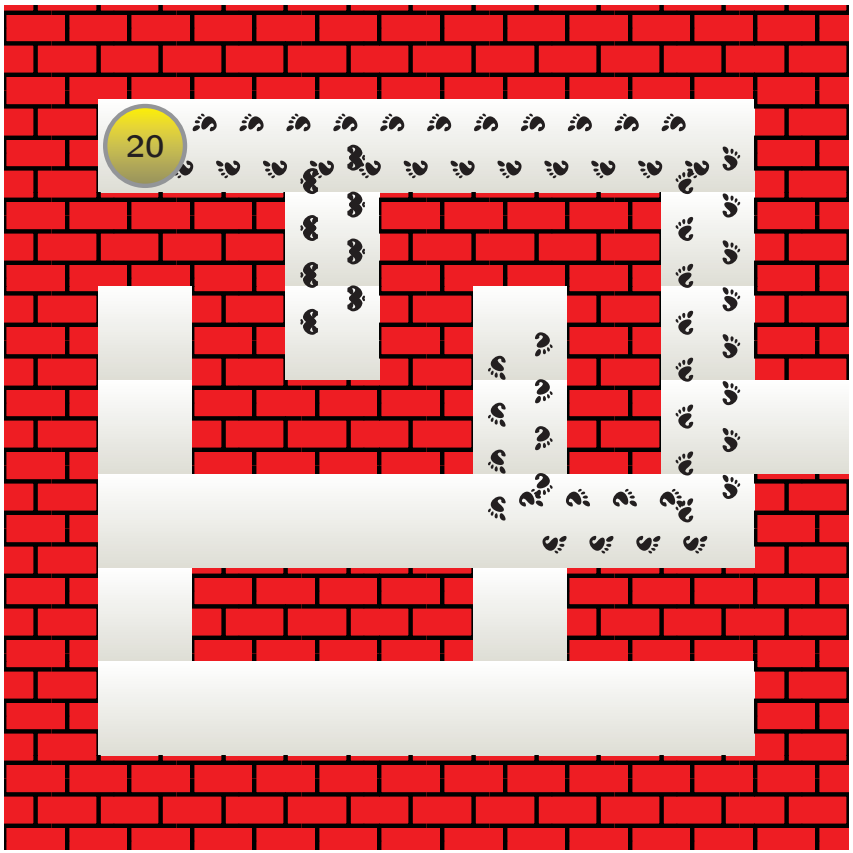

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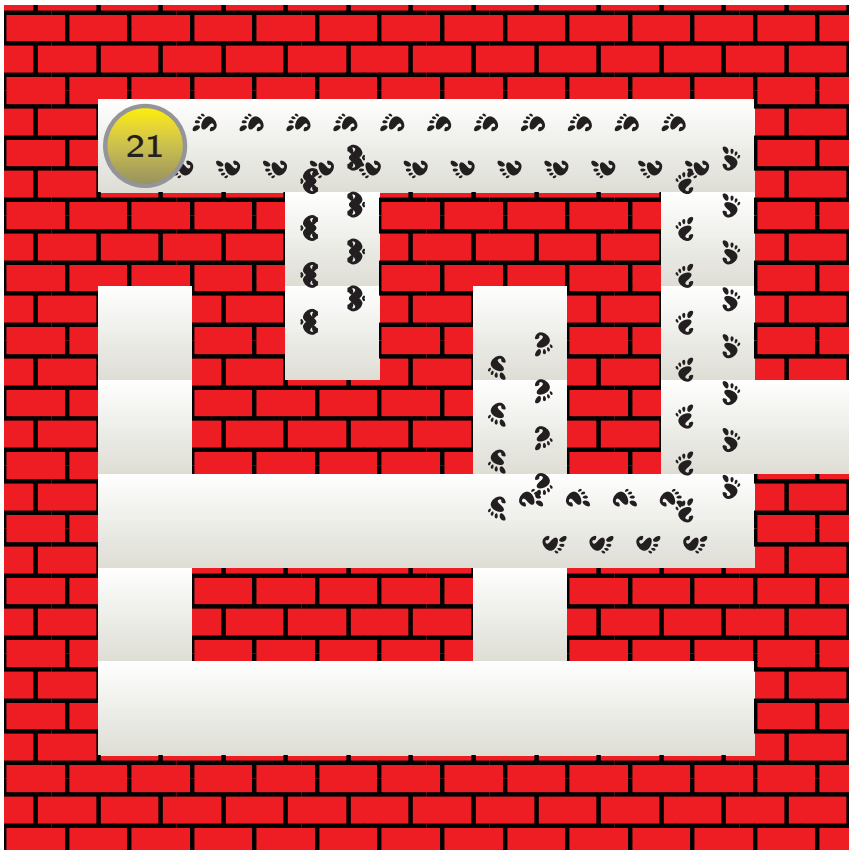

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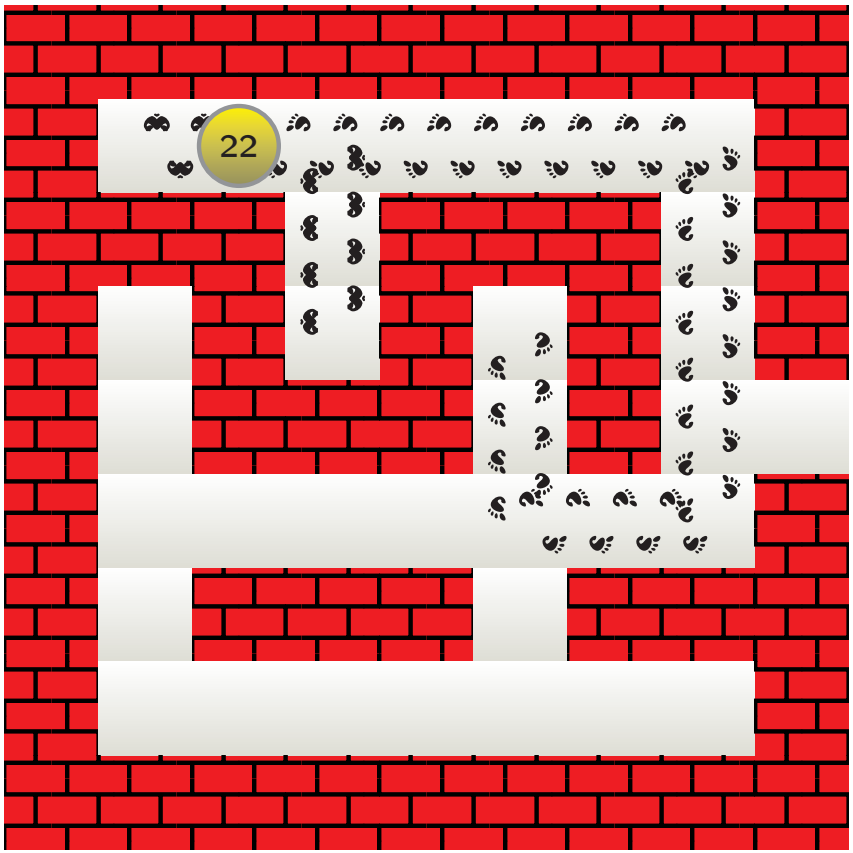

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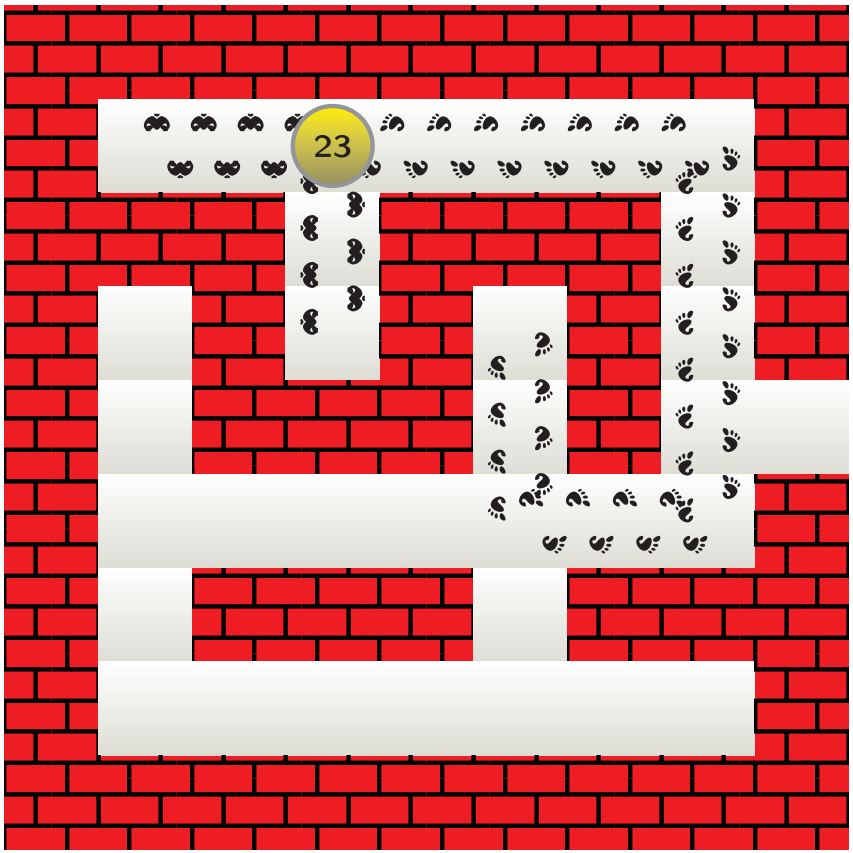

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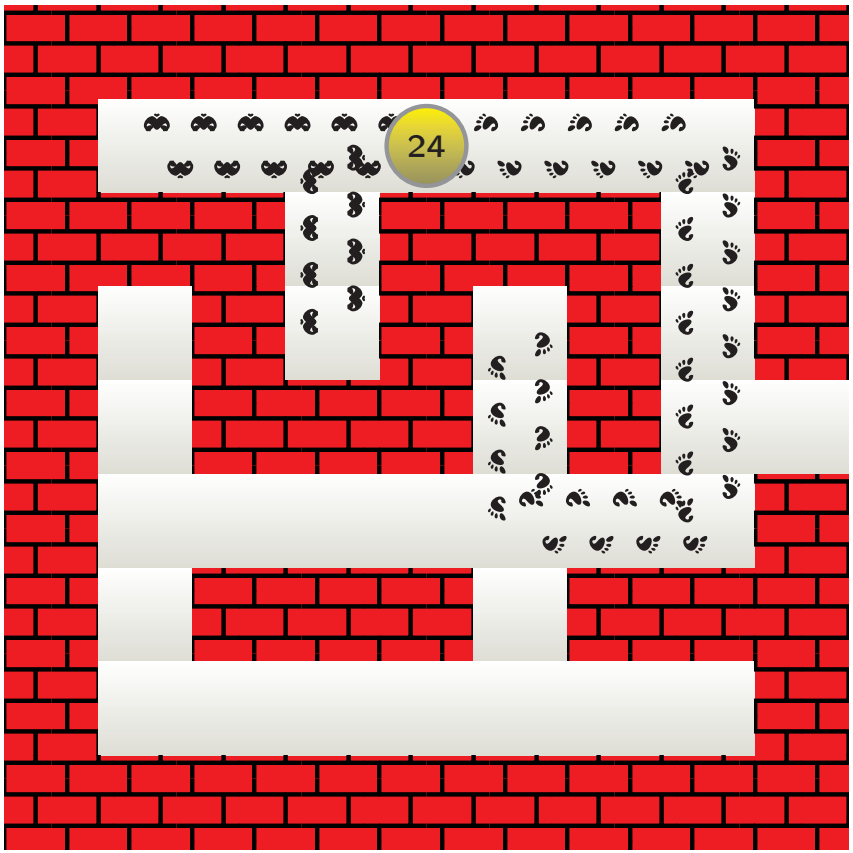

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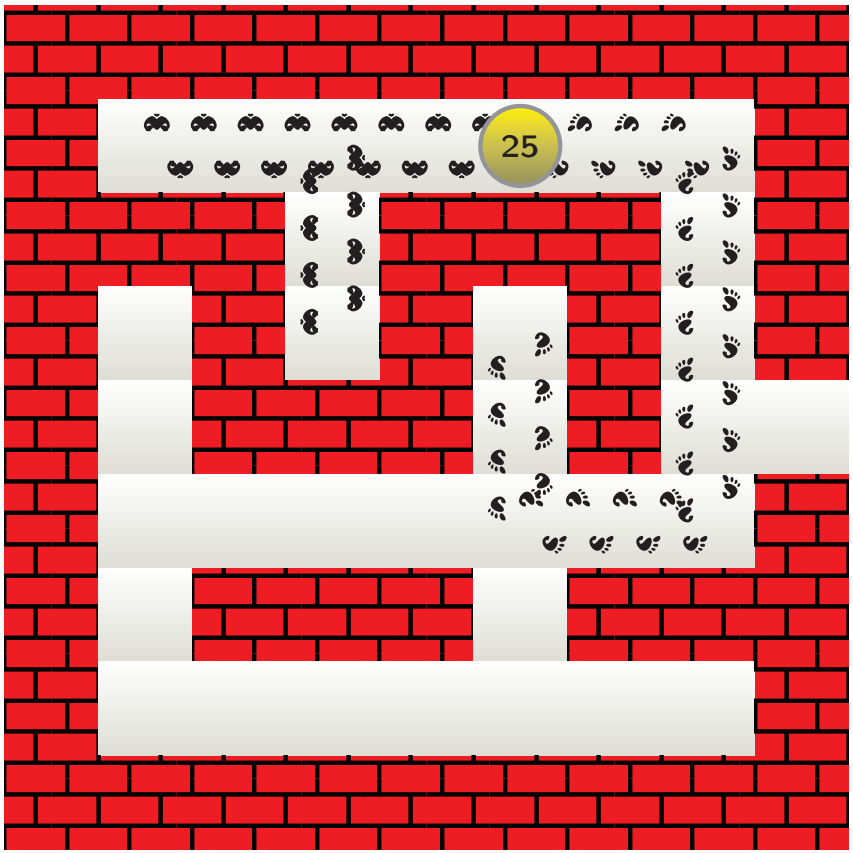

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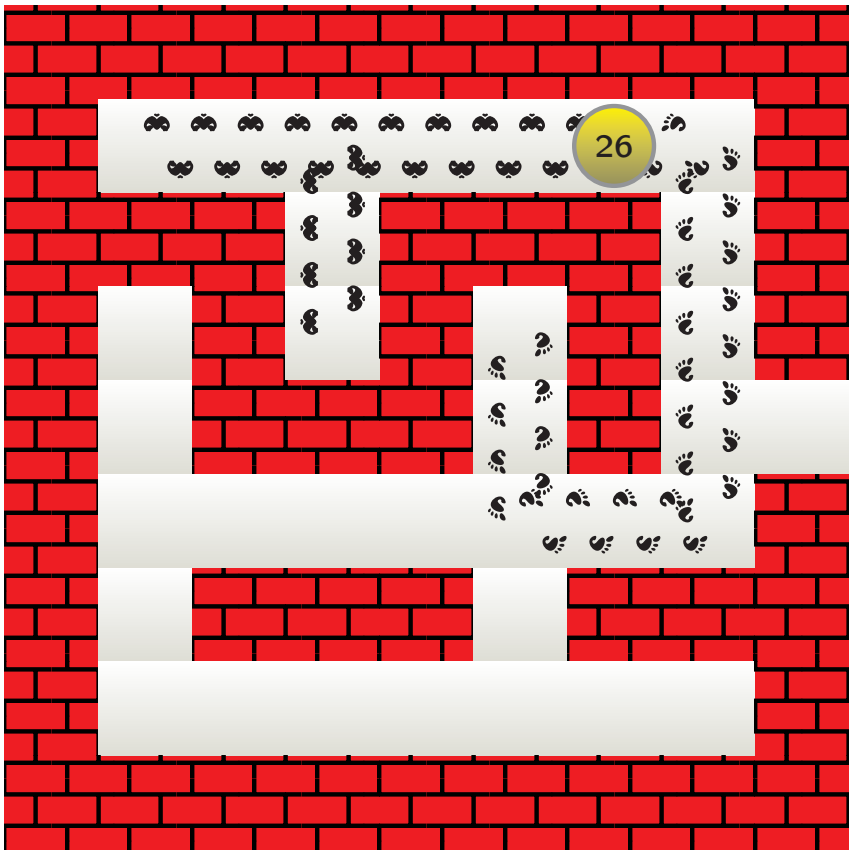

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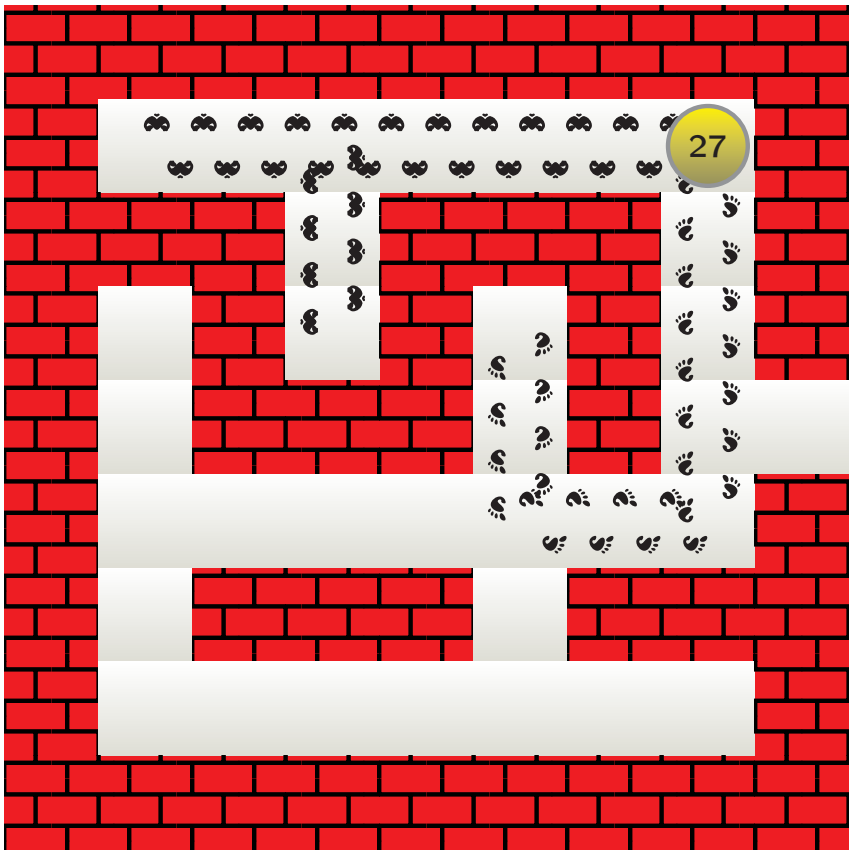

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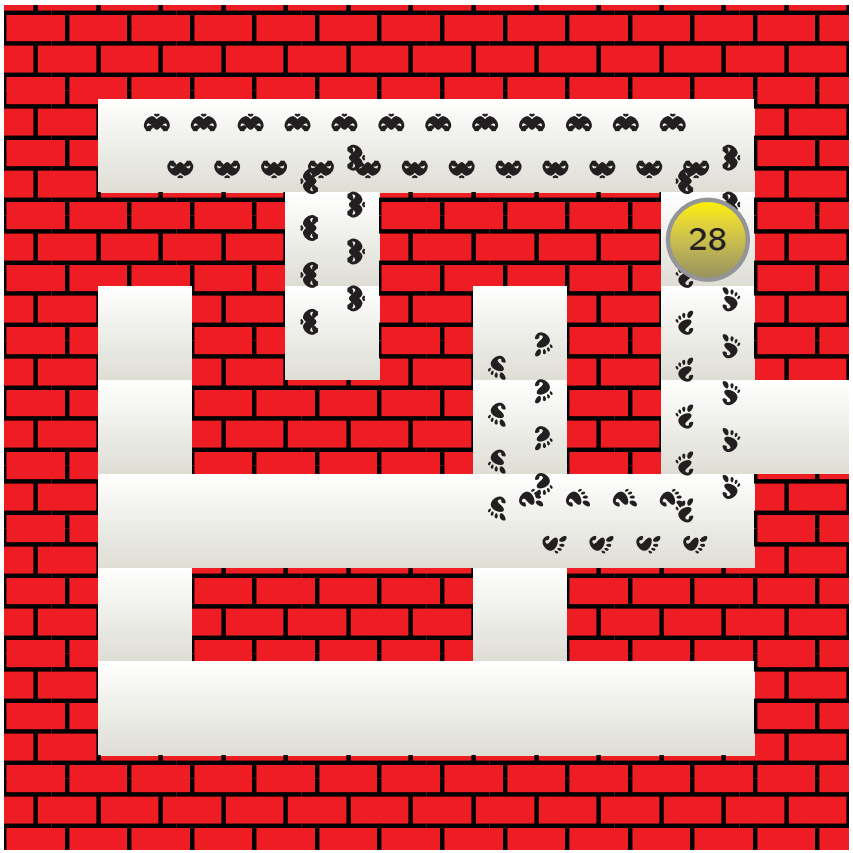

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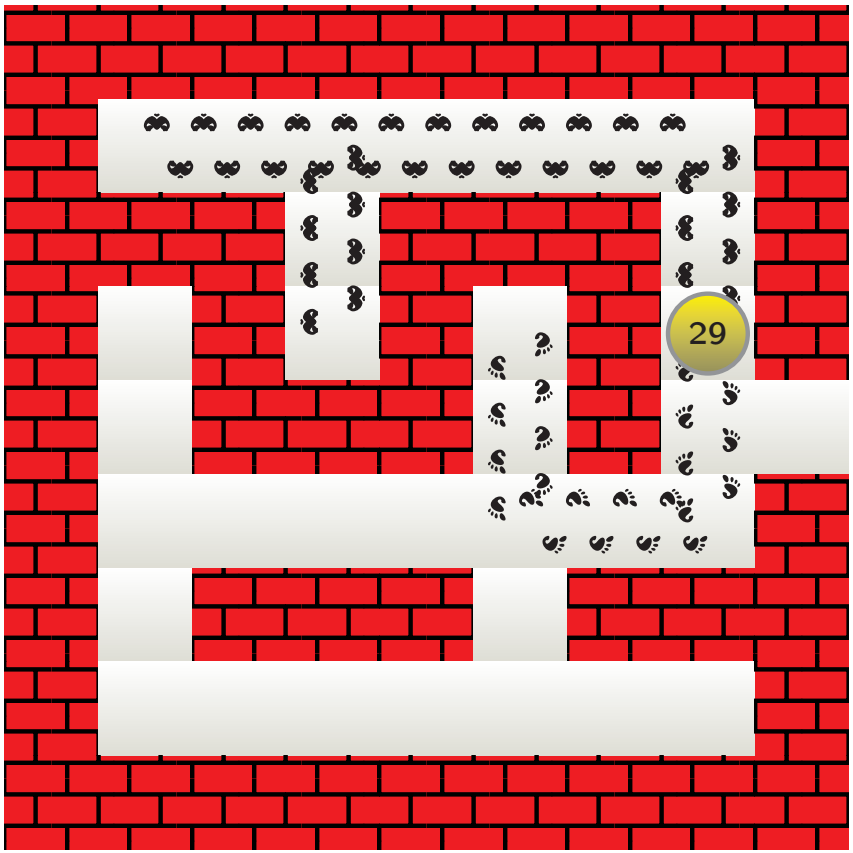

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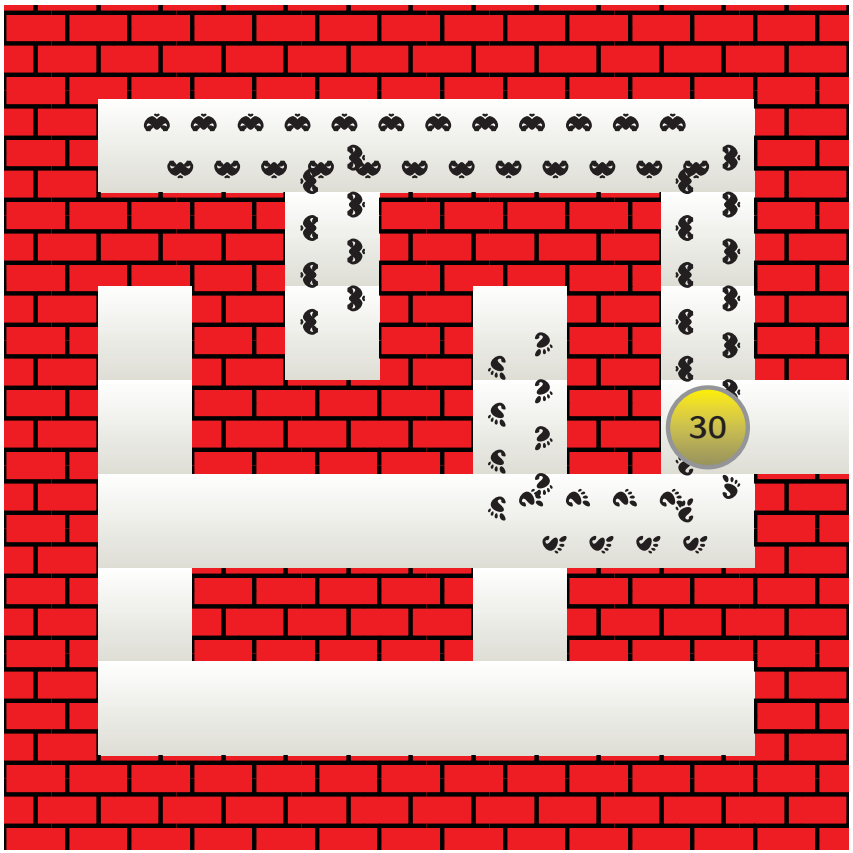

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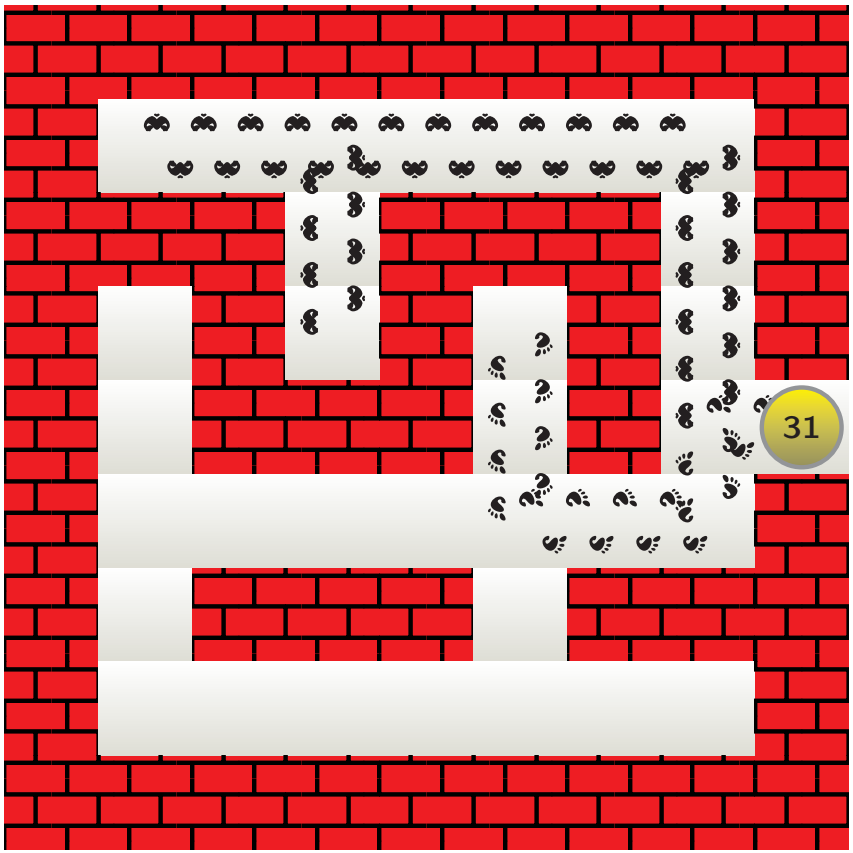

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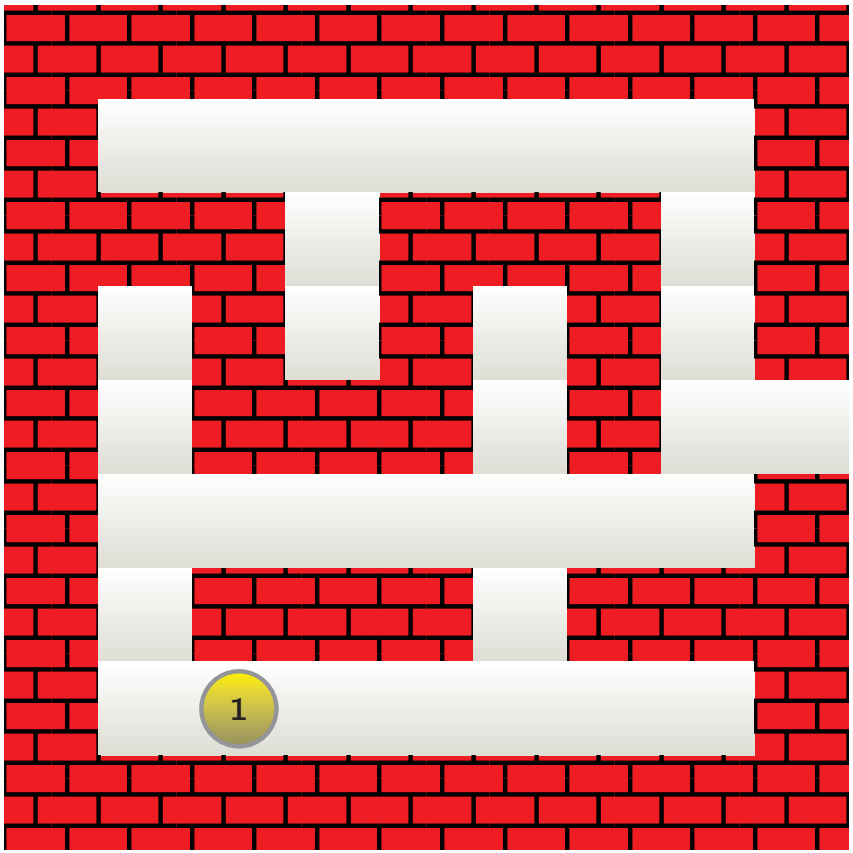

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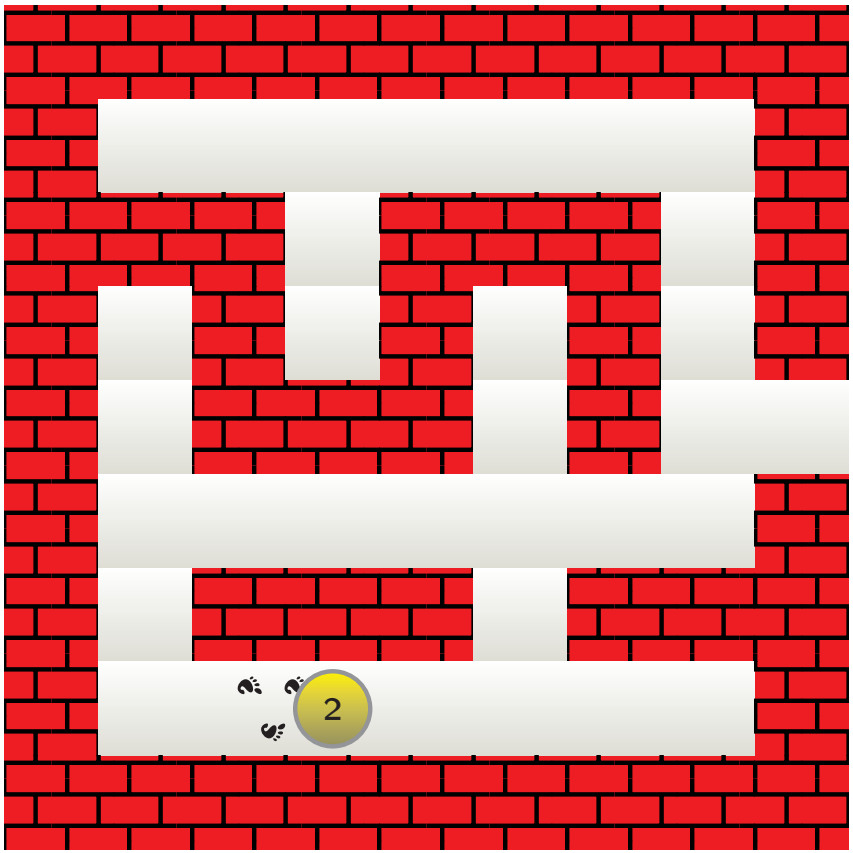

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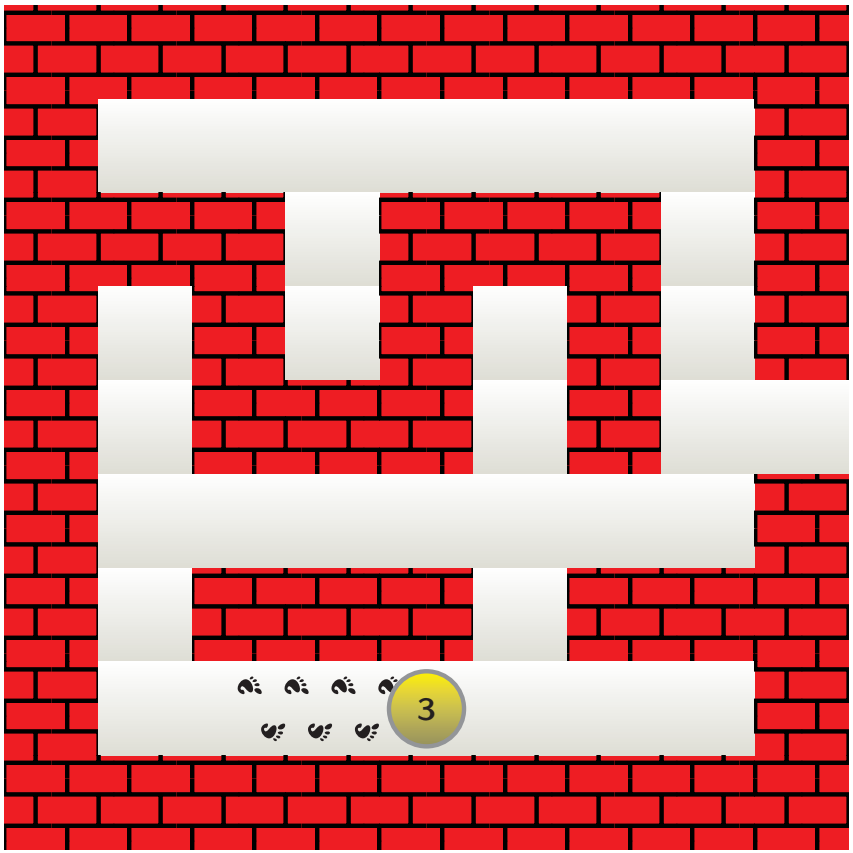

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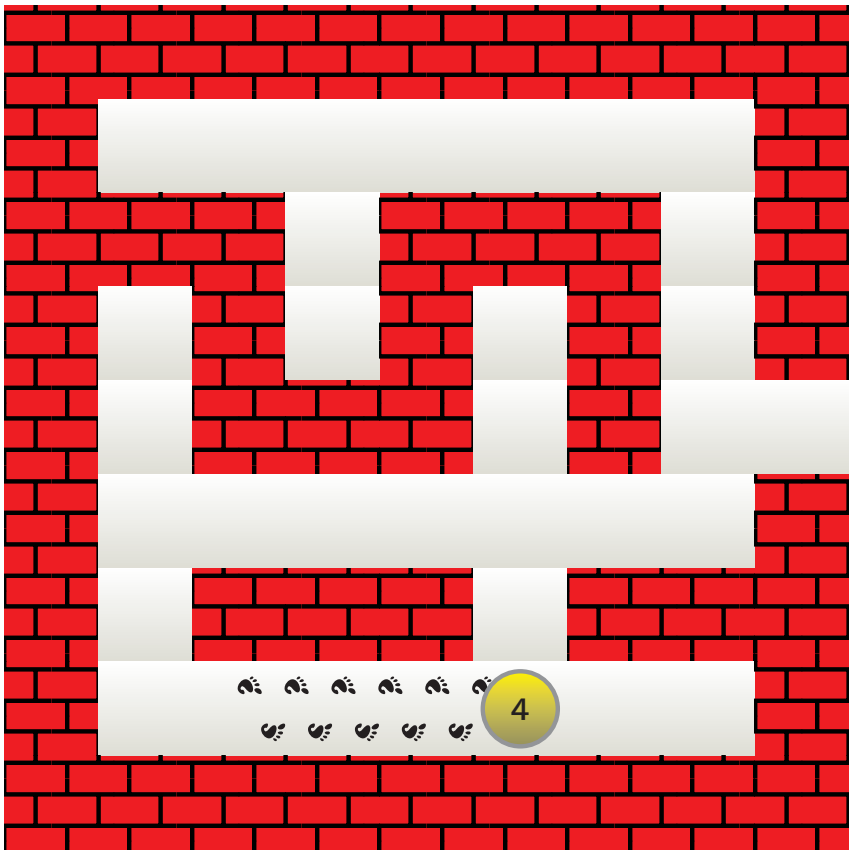

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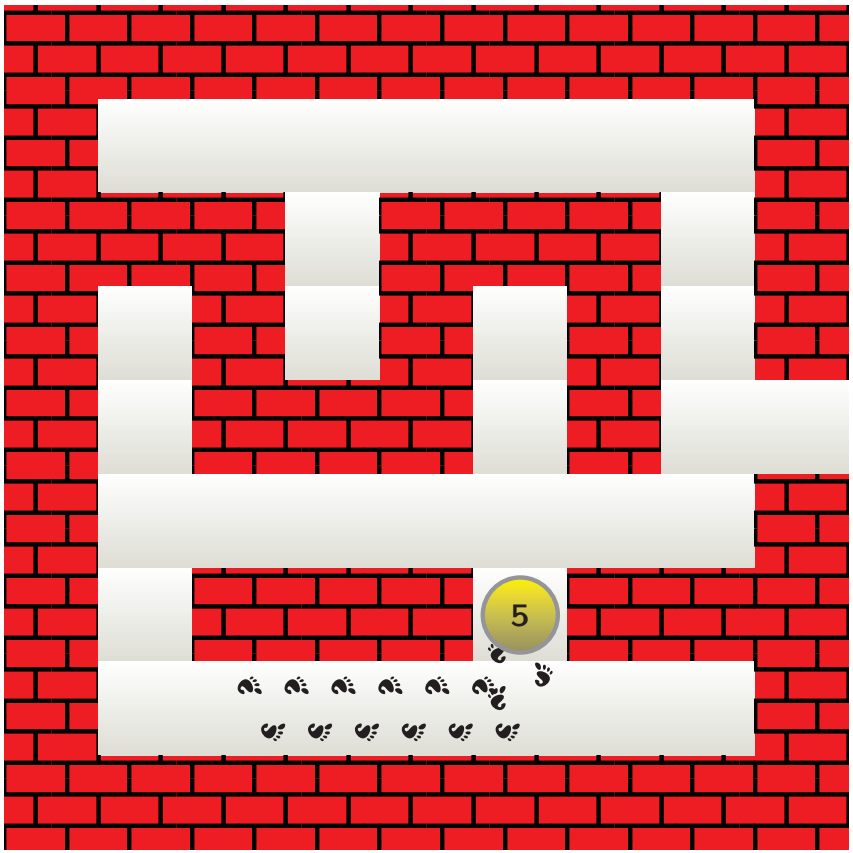

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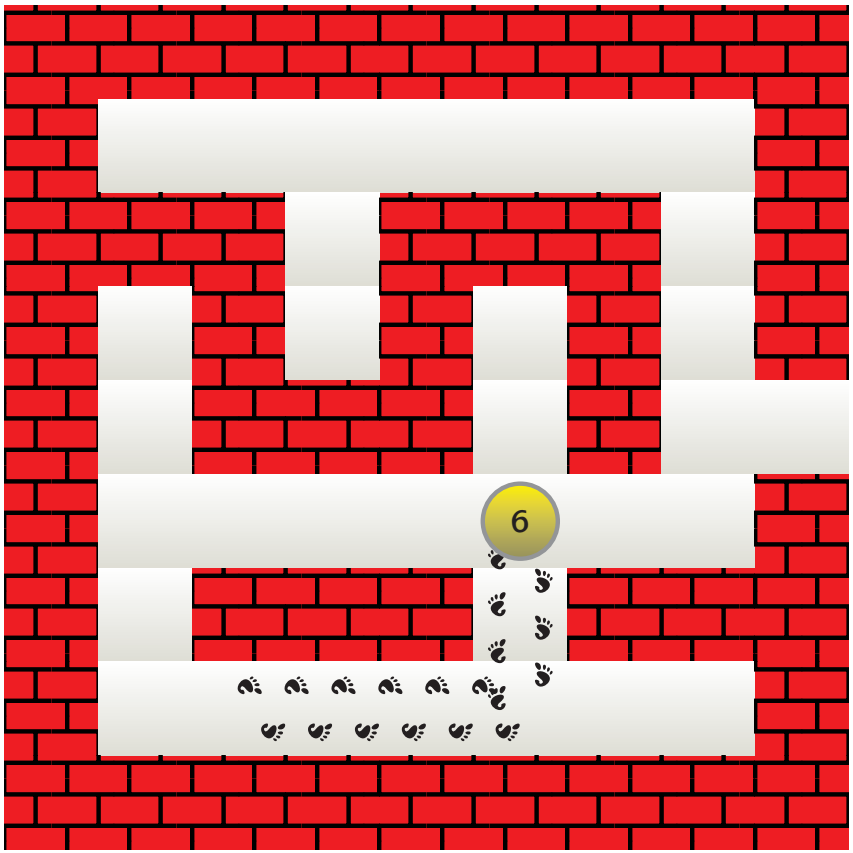

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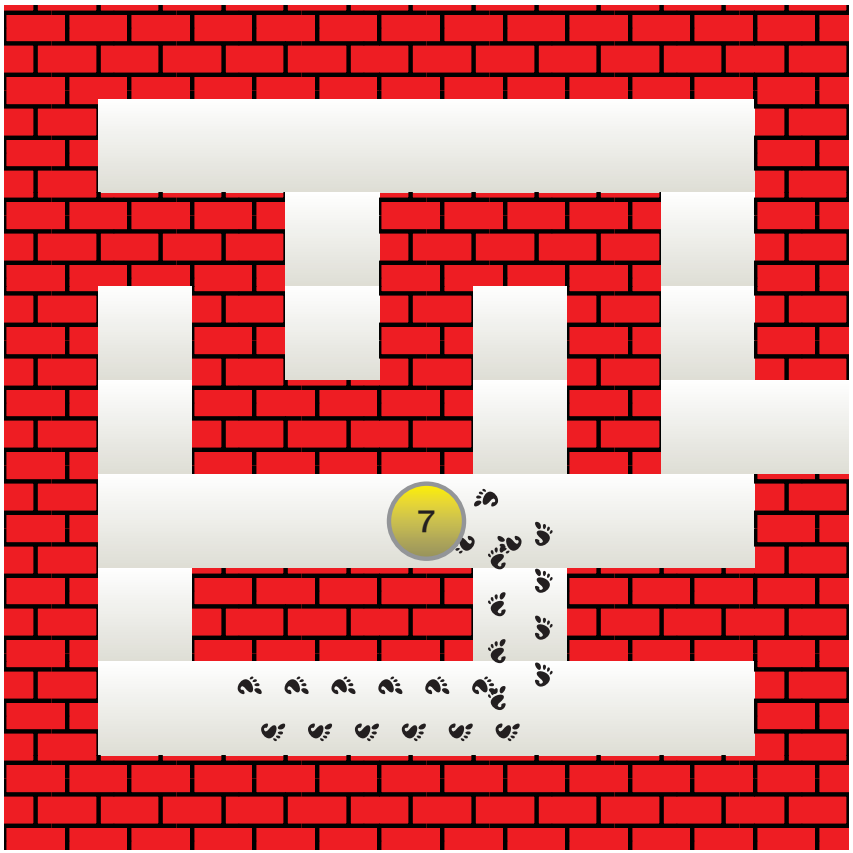

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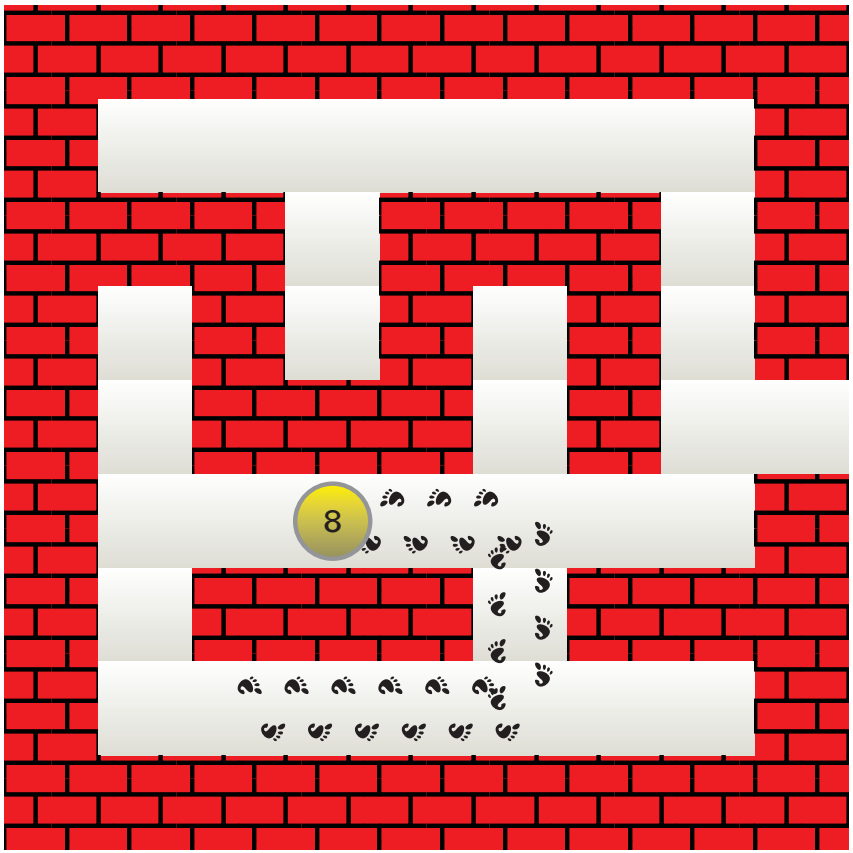

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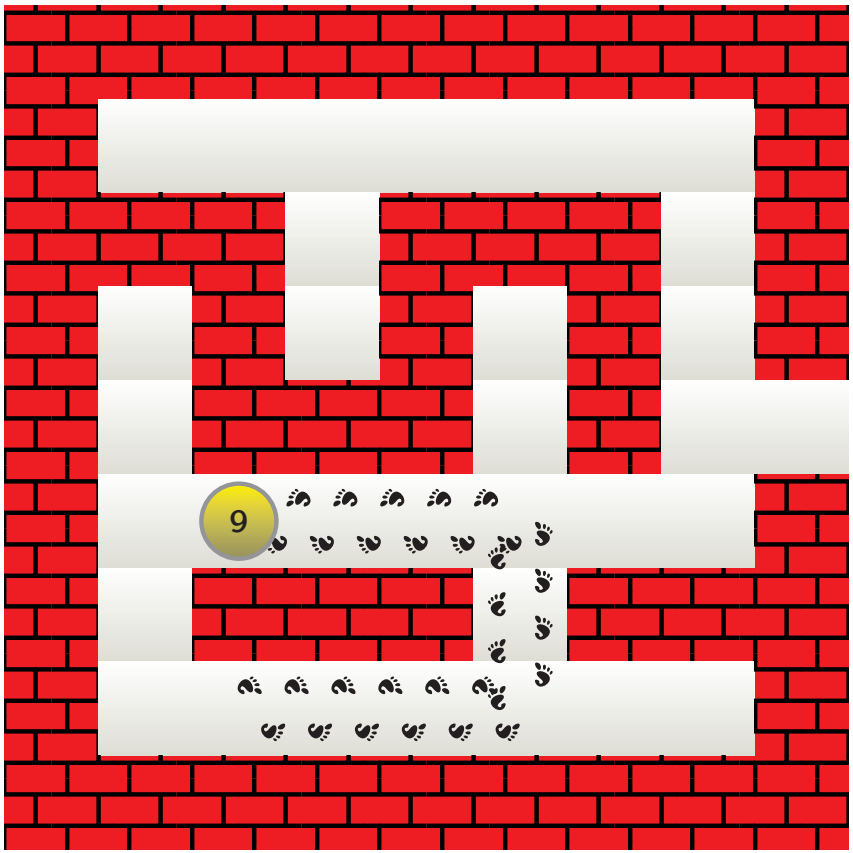

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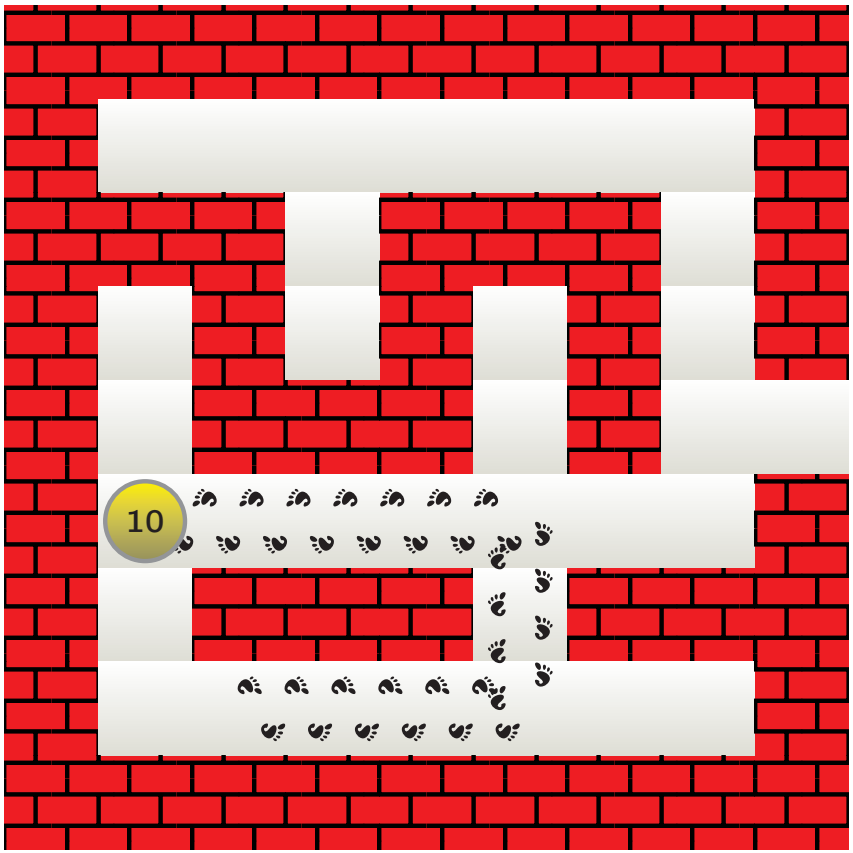

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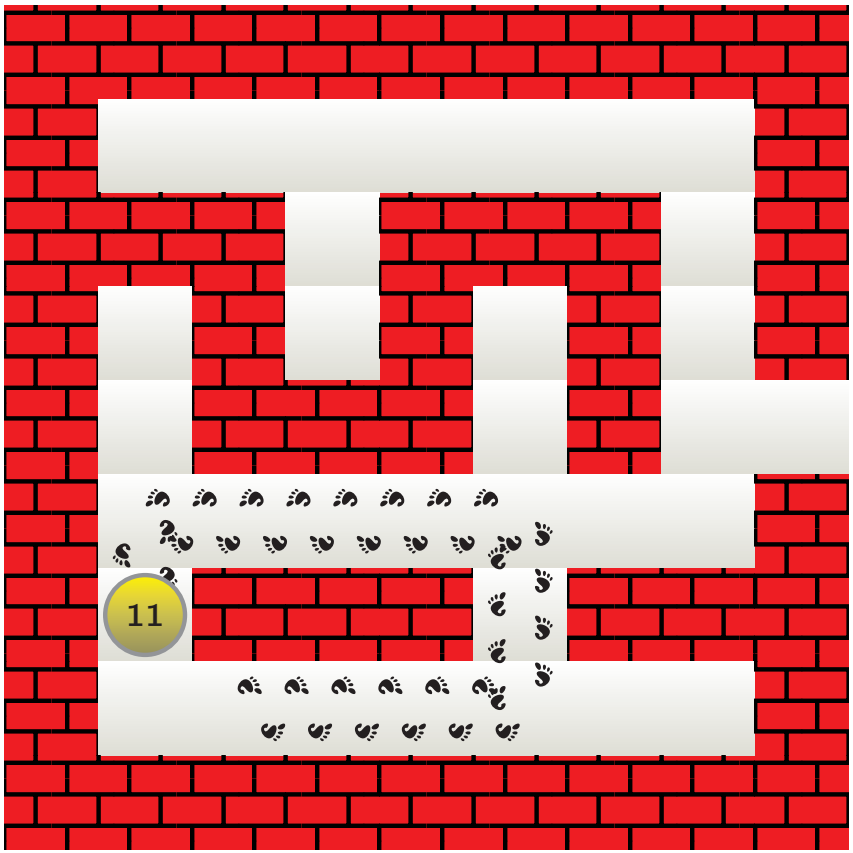

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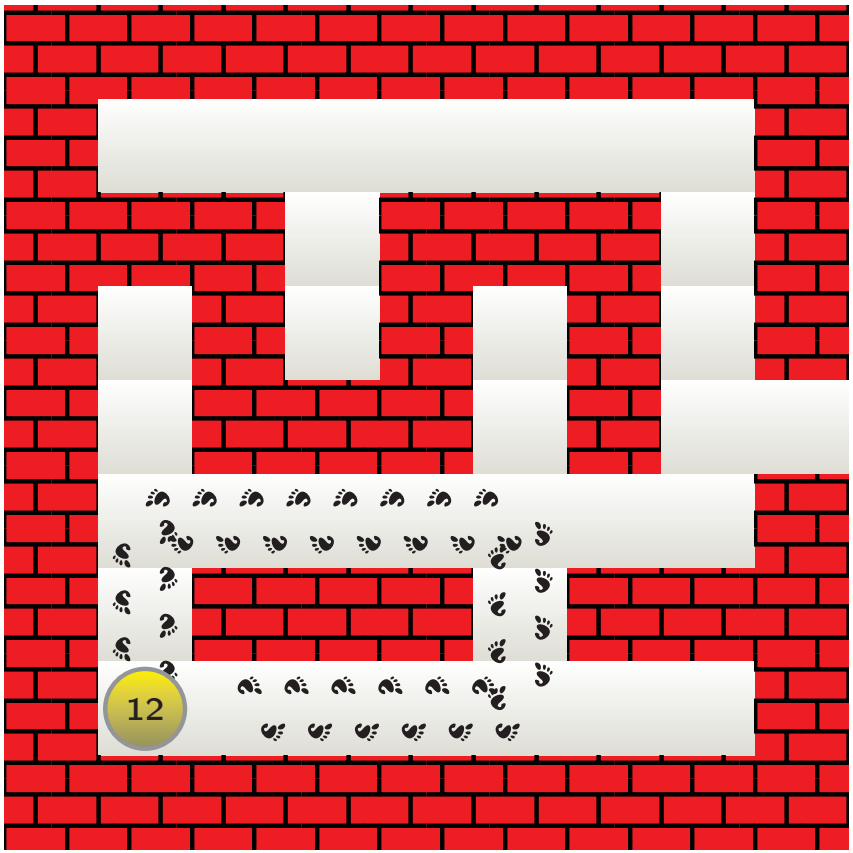

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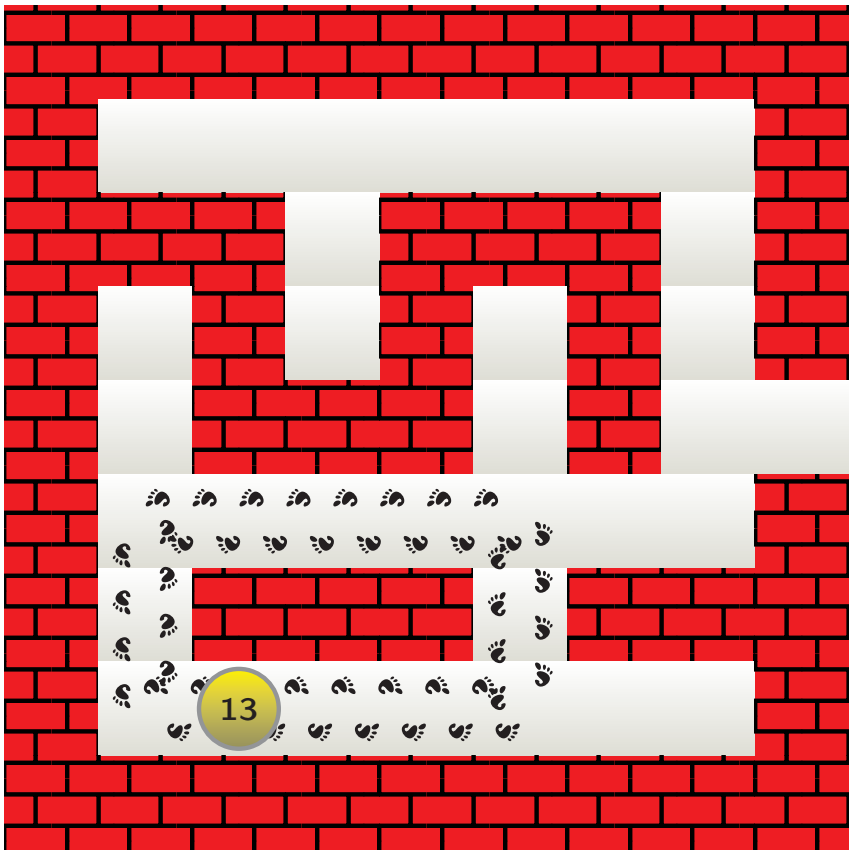

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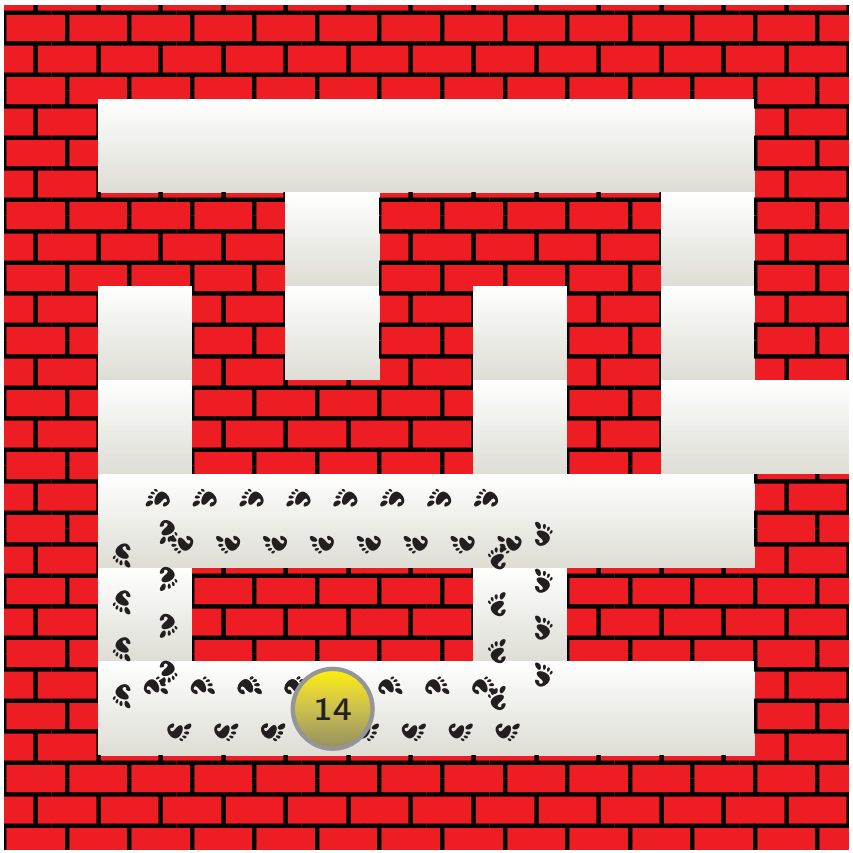

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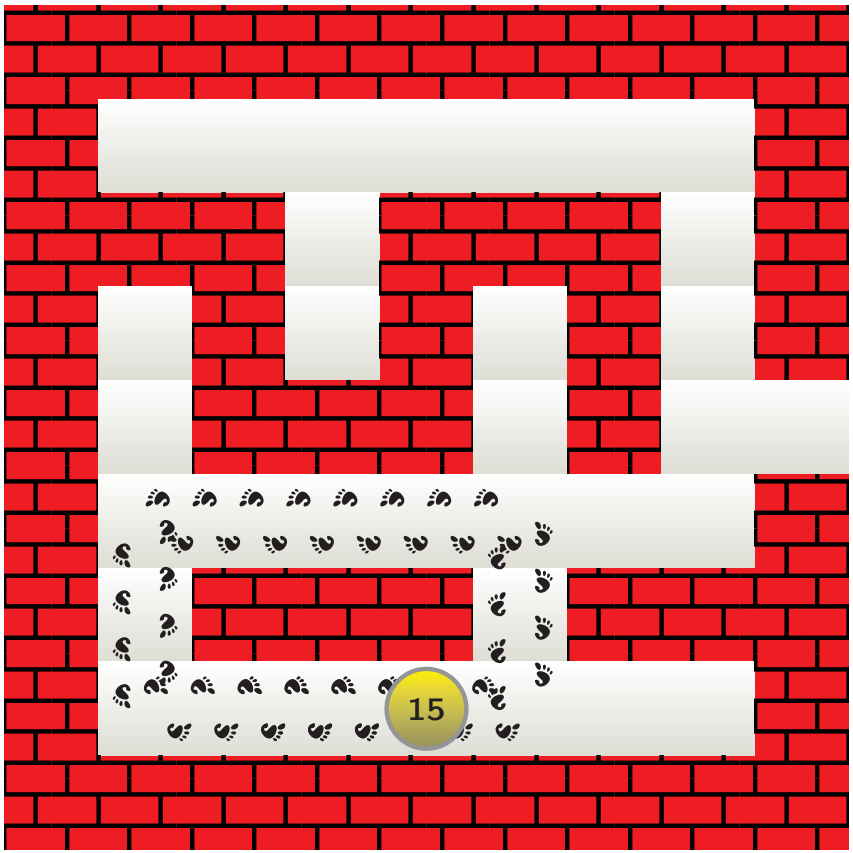

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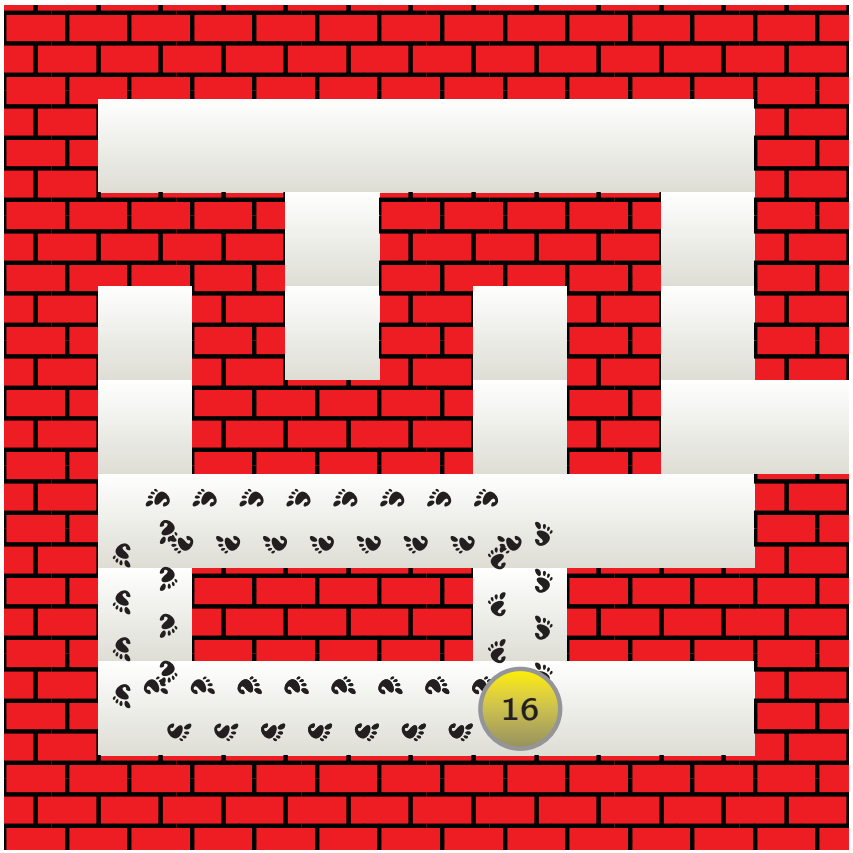

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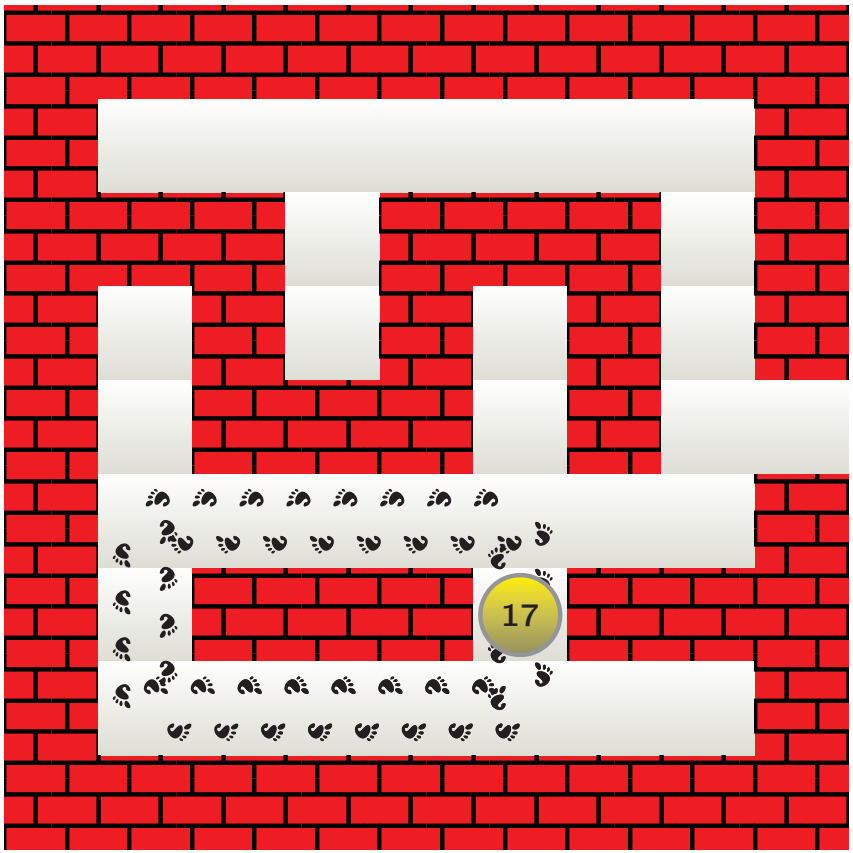

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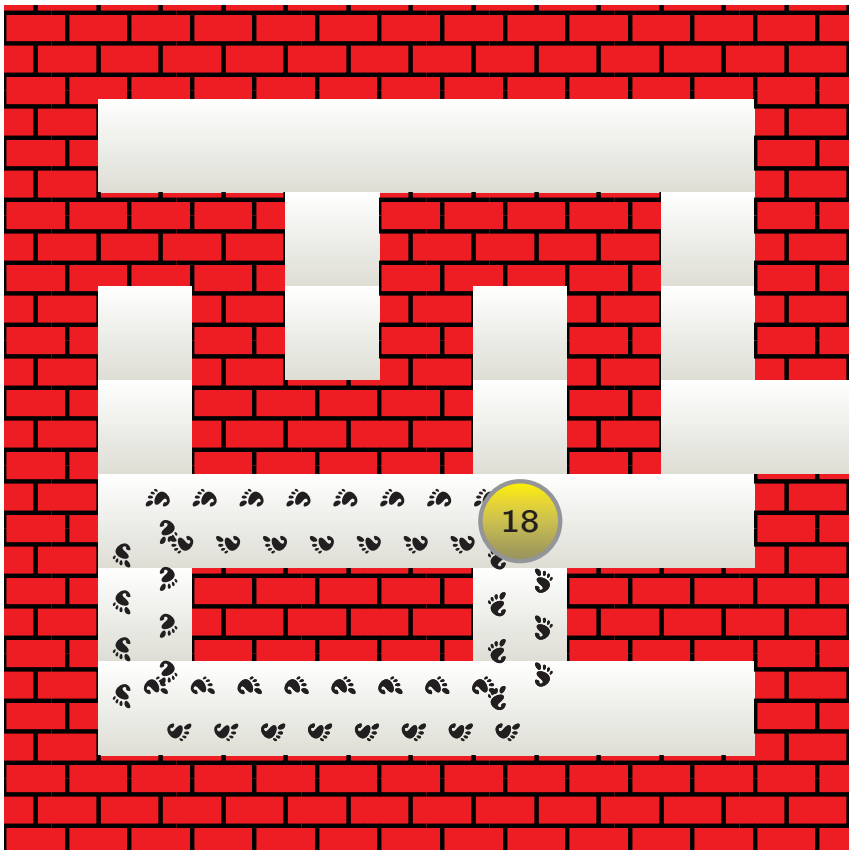

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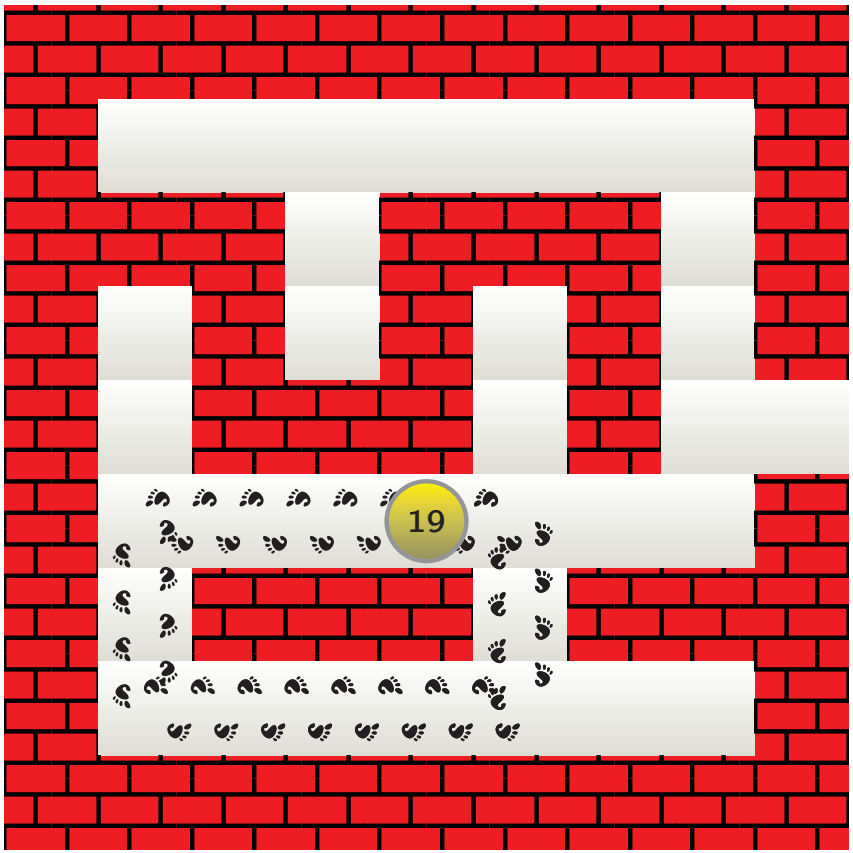

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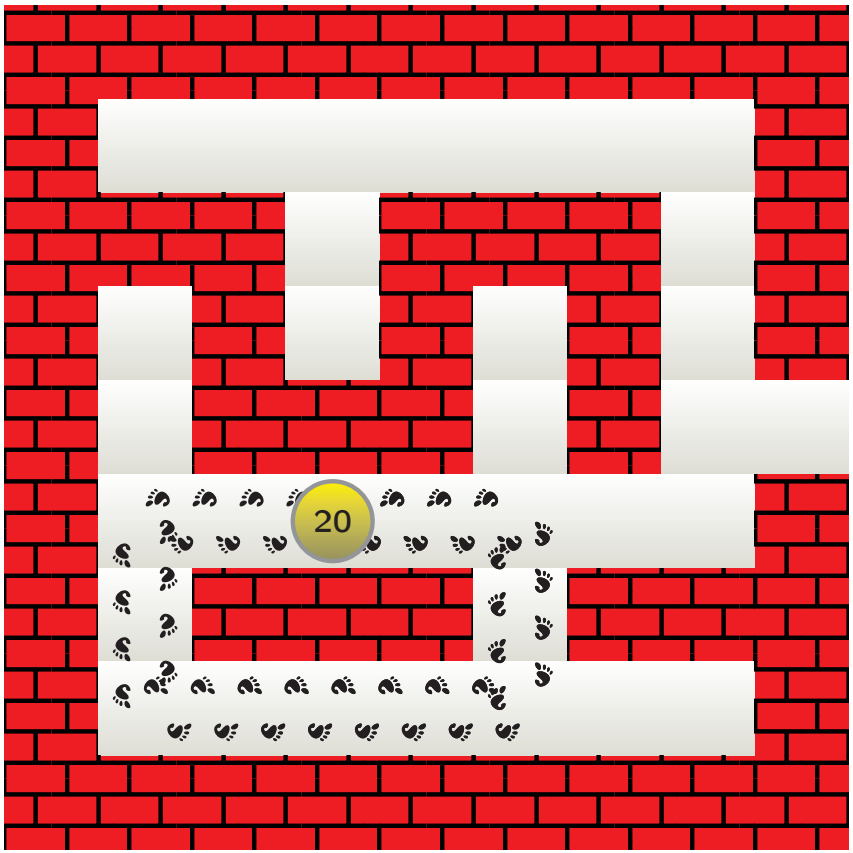


Algorithms – examples

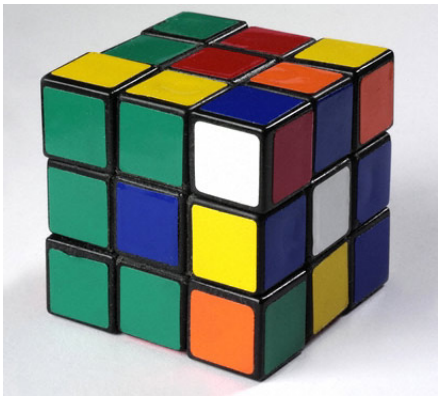
- Even if the algorithm is right, complete and finite, it might be not manageable (not tractable)

Algorithms – examples

- Even if the algorithm is right, complete and finite, it might be not manageable (not tractable)
- It is important to be finite also in practice, which means
  - should be finished within acceptable time
  - should work with reasonable amount of data

Algorithms – examples

Eternal Algorithm Find the shortest sequence of steps for solving the Rubik's cube from any arbitrary starting state.



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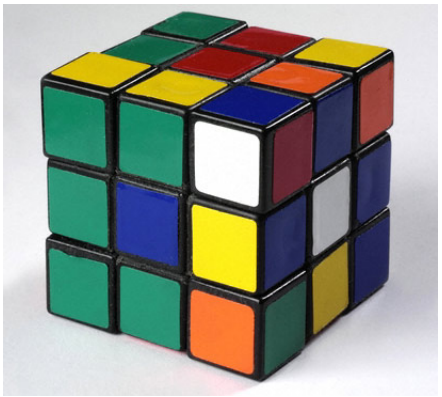

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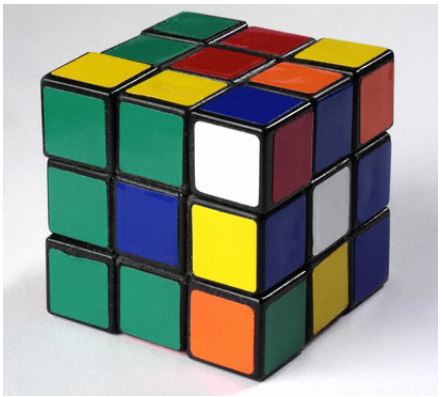

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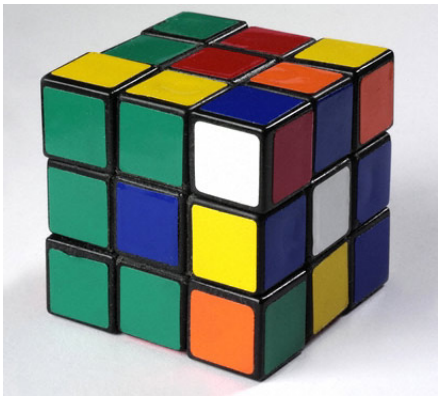

- 21 626 001 637 244 900 000 number of possible states
- If we solve 1 000 000 state per each second, we need 685 756 years to solve all.
- History of mankind is shorter than 10 000 years

Description of algorithms

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- Pseudo-code is a language independent way of describing algorithms
- it is written in a normal (human) language, but it is constructed precisely

```
1  Get a frying pan
2  Put it on the stove (fire)
3  Add some vegetable oil to it
4  Light the fire
5  Wait a little bit
6  Is the oil hot enough?
7  If not, go back to line 5
8  Put some ham in it
9  Wait until the ham gets a bit brown
10 Add three eggs to it
```

Description of algorithms

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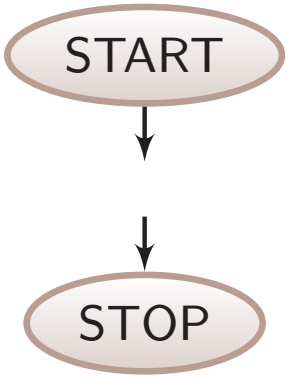
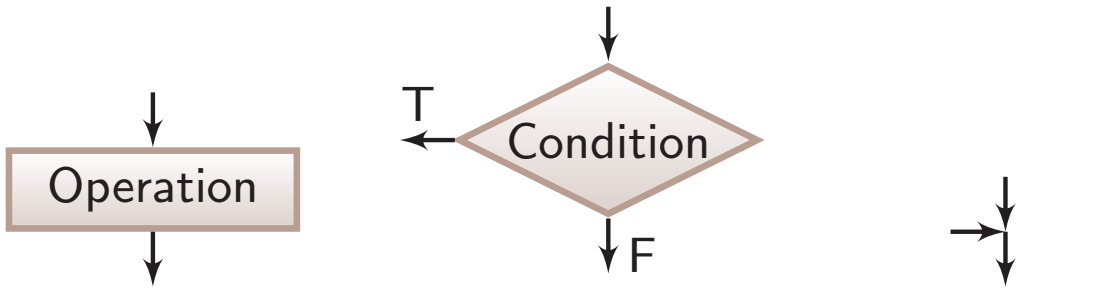
- Flow-chart is a tool for describing algorithms in a graphical way
- The flow-chart of a program with one input and one output is placed between START and STOP elements



- A flow-chart consists of the following elements



operation point of decision connection

Flow-chart – example

- Construct the flow-chart of boiling water

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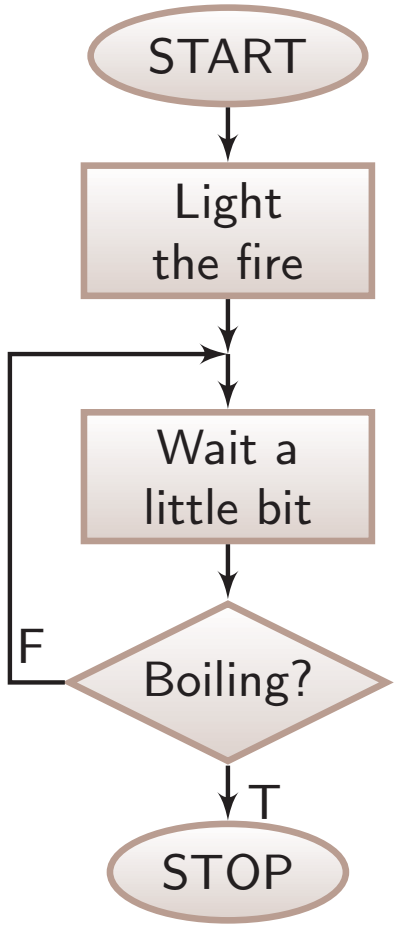

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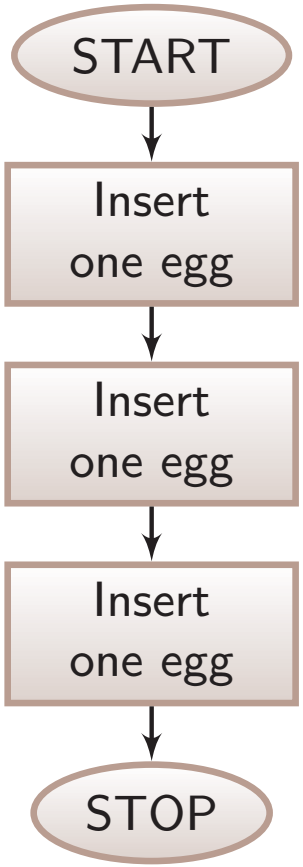

Flow-chart – example

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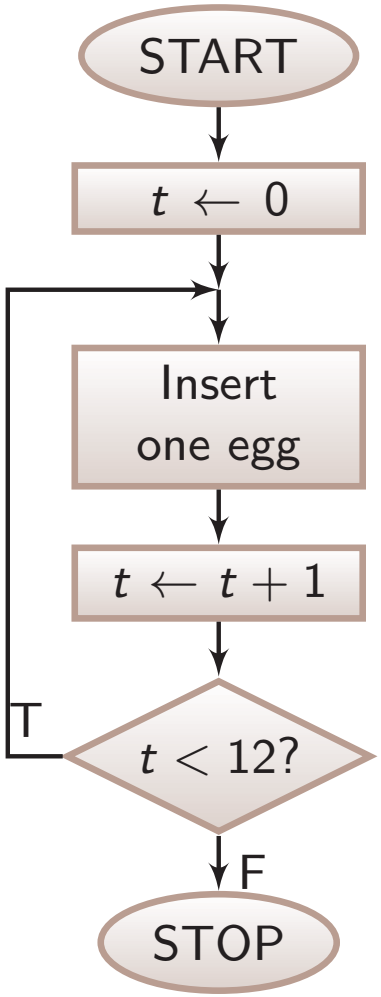

What is data?

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- Algorithm works on data, with data

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  - type (number, letter, colour, . . .)
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Data is everything from the outside world that we somehow represent and store on our computer.

- The data has
  - type (number, letter, colour, . . .)
  - value
- The data determines
  - the set of values the data may have
  - the operations that can be performed on the data

Types – examples

type	values	operations
number	$0, -1, \mathrm{e}, \pi, \ldots$	addition, subtraction, ..., comparison, sorting

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colour	red, blue, ...	comparison
temperature	cold, warm, hot, ...	comparison, sorting

Constants and variables

According to its role in the algorithm, data can be

- constant
  - its value will not change during the execution of the algorithm for example 12 in the example above (the number of eggs to be inserted)
- variable
  - it has an identifier (for example t)
  - its value can be used in operations (reading)
  - its value can be updated (assignment, writing), for example $t \leftarrow 0$
- The type of the constant can be seen from the way it is represented
- The type of the variable always have to be declared (declaration). For example "Let t denote the number of inserted eggs"

Expressions

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- The operations are determined by the operators, the operators work on the operands.
- Examples for expressions

expression	type	value	remark
$2 + 3$	number	5	
$-a$	number	-3	if $a = 3$
$2 * (a - 2)$	number	2	if $a = 3$
true AND false	logical	false	

Expressions

- The type of the expression is not always (not necessarily) the same as the type of the operands. Mixed expressions:

expression	type	value	remark
$2 < 3$	logical	true	
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$(2 < 3) + 5$	logical $+$ number

Programming languages

Programming languages

Mathematical formalism that can be interpreted by the computer

Programming languages

Programming languages

Mathematical formalism that can be interpreted by the computer

- It is similar to spoken languages, in order to be easily understandable and to be easily constructed
- Small vocabulary, very strict grammar (syntax)

Syntax and semantics

- Syntax error (grammatical error)
  - We don't follow the rules of the programming language, the program is not interpretable, it is not executable.
  - Syntax errors are easy to detect.
  - In most of the cases it can be corrected easily, quickly.

Syntax and semantics

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  - Syntax errors are easy to detect.
  - In most of the cases it can be corrected easily, quickly.
- Semantic error (interpretation error)
  - The program is executable, it performs something, but it does not do exactly what we have specified.
  - Semantic error is typically hard to detect and hard to correct.
  - Program testing is a profession.

Chapter 3

C language basics

Short history of C programming language

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- 1972: Start of development at AT&T Bell Labs
  Most of the UNIX kernel was created in C
- 1978: K&R C – Brian Kernigham, Dennis Ritchie:
  The C Programming Language
- 1989: Standardization: ANSI X3.159-1989
- 1999: C99-standard:
  new data types (complex)
  international character encoding
  arrays with variable sizes
  ...
- 2007–: C1X standard, 2011: C11 standard
  C++ compatibility
  multi-thread programs
  ...

Main features of C

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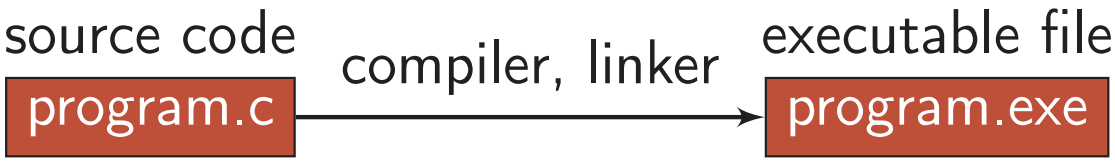
- Compiled language



- "small language": few (10) instructions, a lot of (>50) operators
- concise syntax ("zipped")
  - hard to read (must pay attention)
  - easy to make a mistake
  - hard to find a mistake
- it gives a code that can be optimized efficiently and runs fast
- easy to implement for different platforms

The first C program

- The source code of the minimum-program

```c
/* first.c -- The first program */

int main()
{
  return 0;
}
```

link

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- `int main()` – All C programs starts like this

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- `int main()` – All C programs starts like this
  - `int Main()` – and not like this. C is "case sensitive"

The first C program

- The source code of the minimum-program

```
1  /* first.c -- The first program */
2
3  int main()
4  {
5    return 0;
6  }
```

link

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- `{ }` – block, it encloses the program body
- `return 0;` – It marks the end of the program

The first C program

- . . . that actually does something

```c
/* Helloworld.c -- My first program */
#include <stdio.h> /* needed for printf */

/* The main program */
int main()
{
  printf("Hello world!\n"); /* Printing */
  return 0;
}
```

link

- After compiling and running it gives the following output:

```
Hello world!
```

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}
```

link

- After compiling and running it gives the following output:

```
Hello world!
```

- `#include` – to insert other C program parts
- `printf` – printing, `\n` – new line (line feed)

A more complicated one

- Instructions in a sequence

```c
/* football.c -- football fans */
#include <stdio.h>
int main()
{
  printf("Are you");  /* no new line here */
  printf(" blind?\n"); /* here is new line */
  printf("Go Bayern, go!");
  return 0;
}
```

link

```
Are you blind?
Go Bayern, go!
```

Printing the value of a variable

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```c
#include <stdio.h>
int main()
{
  int n;          /* declaring an integer var., called n */
  n = 2;          /* n <- 2 assignement of value */
  printf("The value is: %d\n", n); /* printing */
  n = -5;         /* n <- 5 assignement of value */
  printf("The value is: %d\n", n); /* printing */
  return 0;
}
```

link

```
The value is:  2
The value is:  -5
```

Printing the value of a variable


```c
#include <stdio.h>
int main()
{
  int n;          /* declaring an integer var., called n */
  n = 2;          /* n <- 2 assignement of value */
  printf("The value is: %d\n", n); /* printing */
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  printf("The value is: %d\n", n); /* printing */
  return 0;
}
```

link

```
The value is:  2
The value is:  -5
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- `int n` – declaration of variable.
  `int` (integer, entier, tamsayi) is the type, `n` is the identifier

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  return 0;
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```

link

```
The value is:  2
The value is:  -5
```

- `int n` – declaration of variable.
  `int` (integer, entier, tamsayi) is the type, `n` is the identifier
- `n = 2` – assignement of value, variable `n` takes value of expression "2"

. . . continued

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```c
#include <stdio.h>
int main()
{
  int n;          /* declaring an integer var., called n */
  n = 2;          /* n <- 2 assignement of value */
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  n = -5;         /* n <- 5 assignement of value */
  printf("The value is: %d\n", n); /* printing */
  return 0;
}
```

link

- `printf(<format>, <what>)` – printing the value of expression `<what>` in the given `<format>` format
  - `%d` – decimal (decimal number system)

Block and declaration

Structure of the block

```
{
  <declarations>
  <instructions>
}
```

```
1  {
2    /* declarations */
3    int n;
4
5    /* instructions */
6    n = 2;
7    printf("%d\n", n);
8  }
```

Block and declaration

Structure of declaration

```
<type name> <identifier> [ = <initial value>]opt ;
```

```
1  int n;                       /* not initialized */
2  int number_of_dogs = 2;      /* initialized */
```

- value of `n` is garbage from memory at the beginning
- value of `number_of_dogs` is 2 at the beginning

Inputting data

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```c
/* square.c -- square of a number */
#include <stdio.h>
int main()
{
  int num;       /* declaring an integer var. */
  printf("Please give an integer value: "); /* info */
  scanf("%d", &num);                        /* inputting */
  /* printing the value of 2 expressions */
  printf("The square of %d is: %d\n", num, num*num);
  return 0;
}
```

link

```
Please give an integer value:  8
The square of 8 is:  64
```

Inputting data

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

```c
/* square.c -- square of a number */
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int main()
{
  int num;       /* declaring an integer var. */
  printf("Please give an integer value: "); /* info */
  scanf("%d", &num);                        /* inputting */
  /* printing the value of 2 expressions */
  printf("The square of %d is: %d\n", num, num*num);
  return 0;
}
```

link

```
Please give an integer value:  8
The square of 8 is:  64
```

- `scanf(<format>, &<where to>)` – Inputting (scanning) data in `<format>` format and putting it into `<where to>` variable

Inputting data

- This is another option, that gives the same result.

```
1 #include<stdio.h>int main(){int num; printf
2 ("Please give an integer value: ");scanf("%d",
3     &num);printf("The square of %d is: %d\n",
4             num,num*num);return
5                     0;}
```

link

Inputting data

- This is another option, that gives the same result.

```
1 #include<stdio.h>int main(){int num; printf
2 ("Please give an integer value: ");scanf("%d",
3     &num);printf("The square of %d is: %d\n",
4             num,num*num);return
5                     0;}
```

link

- Of course, it is better to think about others!

Thank you for your attention.