

# Beautiful IO

A tour through standard library `pkg/io` and various implementations of its interfaces.

Golab 2019, 2019–10–21, Florence

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# About me

SWE [@ubleipzig](#) working mostly with Python and Go.

Taming data – open source – writing.

| [Explore IO](#) workshop at Golab 2017.

# Background

- Go Proverbs (2015)

| The bigger the interface, the weaker the abstraction.

Prominent examples are `io.Reader` and `io.Writer`.

# The IO package

- contains basic, widely used interfaces (within and outside standard library)
- utility functions

# Why beautiful?

La bellezza è negli occhi di chi guarda

- small, versatile interfaces
- composable

# Praise and love

This article aims to convince you to use `io.Reader` in your own code wherever you can. -- [@matryer](#)

"Crossing Streams: a love letter to Go `io.Reader`" -- [@jmoiron](#)

Which brings me to `io.Reader`, easily my favourite Go interface. --  
[@davecheney](#)

# What's in pkg/io?

- 25 types
- 21/25 are interfaces
- 12 functions, 3 constants, 6 errors

The concrete types are: `LimitedReader`, `PipeReader`, `PipeWriter`, `SectionReader`; functions: `Copy`, `CopyN`, `CopyBuffer`, `Pipe`, `ReadAtLeast`, `ReadFull`, `WriteString`, `LimitReader`, `MultiReader`, `TeeReader`, `NewSectionReader`, `MultiWriter`

# A few Interfaces

	R	W	C	S
io.Reader	x			
io.Writer		x		
io.Closer			x	
io.Seeker				x
io.ReadWriter	x	x		
io.ReadCloser	x		x	
io.ReadSeeker	x			x
io.WriteCloser		x	x	
io.WriteSeeker		x		x
io.ReadWriteCloser	x	x	x	
io.ReadWriteSeeker	x	x		x



# Missing interfaces

You might find some missing pieces elsewhere.

```
https://github.com/go4org/go4/blob/94abd6928b1da39b1d757b60c93fb2419c409  
... 33 // A ReadSeekCloser can Read, Seek, and Close.  
34 type ReadSeekCloser interface {  
35     io.Reader  
36     io.Seeker  
37     io.Closer  
38 }  
39  
40 type ReaderAtCloser interface {  
41     io.ReaderAt  
42     io.Closer  
43 }
```

# How many readers, writers are there?

```
$ guru -json implements /usr/local/go/src/io/io.go:#3309,#3800
```

I counted over 200 implementations of each, `io.Reader` and `io.Writer` in the Go tree and subrepositories.

# What is a Reader?

```
type Reader interface {  
    Read(p []byte) (n int, err error)  
}
```

The reader implementation will populate a given byte slice.

- at most `len(p)` bytes are read
- to signal the end of a stream, return `io.EOF`

There is some flexibility around the end of a stream.

Callers should always process the  $n > 0$  bytes returned before considering the error `err`. Doing so correctly handles I/O errors that happen after reading some bytes and also both of the allowed EOF behaviors.

# Notes

```
type Reader interface {  
    Read(p []byte) (n int, err error)  
}
```

- The byte slice is under the control of the caller.

Implementations must not retain p.

This hints at the streaming nature of this interface.

# Implementations

- files
- network connections
- HTTP response bodies
- standard input and output
- compression
- hashing
- encoding
- formatting
- ...

Many uses in testing as well.

# Structural typing

- conversions are not required, a file implements `Read` and hence *is* a `io.Reader`



The screenshot shows the Stack Overflow interface. The header includes the Stack Overflow logo, a 'Products' link, a search bar, and a notification icon with '139'. The left sidebar contains navigation links: 'Home', 'PUBLIC', 'Stack Overflow' (selected), 'Tags', 'Users', 'Jobs', 'TEAMS', 'What's this?', and 'First 10 Free'. The main content area displays a question titled 'Create a io.Reader from a local file'. Below the title, it says 'Asked 5 years, 1 month ago', 'Active 1 month ago', and 'Viewed 58k times'. The question text is 'I would like to open a local file, and return a `io.Reader`. The reason is that I need to feed a `io.Reader` to a library I am using, like:'. Below the text is a code block containing a Go function signature: 

```
func read(r io.Reader) (results []string) {  
    }  
}
```

. To the left of the code block are up and down vote arrows, the number '67', a star icon, and the number '8'. At the bottom of the question are 'go' and 'Edit tags' buttons.

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## Create a io.Reader from a local file

Asked 5 years, 1 month ago Active 1 month ago Viewed 58k times

I would like to open a local file, and return a `io.Reader`. The reason is that I need to feed a `io.Reader` to a library I am using, like:

```
func read(r io.Reader) (results []string) {  
    }  
}
```

67

8 go Edit tags

# Streams

As layed out in the *love letter*, the use of `ioutil.ReadAll` is debatable. It's in the standard library and useful, but not always necessary.

```
b, err := ioutil.ReadAll(r)  
...
```

# Streams

- you may lose the advantage to use the `Reader` in other places
- you may consume more memory

Streams can trivially produce infinite output while using barely any memory at all - imagine an implementation behaving like `/dev/zero` or `/dev/urandom`.

- Memory control is an important advantage.



# Follow the stream

Instead of writing:

```
b, _ := ioutil.ReadAll(resp.Body) // Pressure on memory.  
fmt.Println(string(b))
```

You may want to connect streams:

```
_, _ = io.Copy(os.Stdout, resp.Body)
```

# Stream advantages

- memory efficient
- can work with data, that does not fit in memory
- allows to work on different protocol parts differently (e.g. HTTP header vs HTTP body)

## Another example

We often need to unmarshal JSON.

```
_ = json.Unmarshal(data, &v) // data might come from ioutil.ReadAll(resp.Body)
```

But we can decode it as well.

```
_ = json.NewDecoder(resp.Body).Decode(&v)
```

In this case, the JSON data must be fully read, so this is a weak example.

# Glipse at composition

But what is we want need to preprocess the data, e.g. decompress it. Streams compose well.

```
zr, _ = gzip.NewReader(resp.Body)
_ json.NewDecoder(zr).Decode(&
```

# How do you implement one yourself?

You only need a `Read` method with the correct signature.

- Example: `/dev/zero`

```
type devZero struct{}

func (r *devZero) Read(p []byte) (int, error) {
    for i := 0; i < len(p); i++ {
        p[i] = '\x00'
    }
    return len(p), nil
}
```

This is already an infinite stream.

# Embed a reader

Often you want to transform a given data stream, so you embed it.

```
type UpperReader struct {
    r io.Reader // Underlying stream
}

func (r *UpperReader) Read(p []byte) (int, error) {
    n, err := r.r.Read(p)
    copy(p, bytes.ToUpper(p))
    return n, err
}

func main() {
    if _, err := io.Copy(os.Stdout, &UpperReader{os.Stdin}); err != nil {
        log.Fatal(err)
    }
}
```

- Also try: <https://tour.golang.org/methods/22> (Reader exercise, ROT13)

# The io.Writer interface

Analogous to the `io.Reader` interface.

```
type Writer interface {  
    Write(p []byte) (n int, err error)  
}
```

Write writes `len(p)` bytes from `p` to the underlying data stream. It returns the number of bytes written from `p` ( $0 \leq n \leq \text{len}(p)$ ) and any error encountered that caused the write to stop early.

Write must return a non-nil error if it returns  $n < \text{len}(p)$ . Write must not modify the slice data, even temporarily.

As with readers:

Implementations must not retain `p`.

# An example

A writer that does not much, but is still useful - `/dev/null` in Go:

```
type devNull struct{}

func (w *devNull) Write(p []byte) (int, error) {
    return len(p), nil
}

func main() {
    if n, err := io.Copy(&devNull{}, strings.NewReader("Hello World")); err != nil {
        log.Fatal(err)
    } else {
        log.Printf("%d bytes copied", n)
    }
}
```

The standard library implementation is called `ioutil.Discard` (for an interesting/frustrating bug related to `ioutil.Discard`, read [#4589](#)).



## Use case: File

Prototypical stream: A file.

- `os.File`

And alternatives and substitutions, e.g. dummy files for tests or file that support atomic writes.



AT&T Archives: The UNIX Operating System

A file is simply a sequence of bytes. Its main attribute is its size. By

## Use case: Networking

```
type Conn interface {  
    // Read reads data from the connection.  
    // Read can be made to time out and return an Error with Timeout() == true  
    // after a fixed time limit; see SetDeadline and SetReadDeadline.  
    Read(b []byte) (n int, err error)  
    ...  
}
```

