CS 45, Lecture 3
Data Wrangling

Winter 2023

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Administrivia

- Assignment 1 is live! It covers regular expressions and data wrangling. It is due on Monday, January 23rd.
- Our autograder was incorrect for A1, Part 2, Question 2. This has been fixed.
- Office hours are listed on the course website. Come if you need help or want to chat!

What we know

In Lecture 1, we learned how to:

- What the shell is
- What the UNIX philosophy is
- How to run basic commands such as `ls`, `cd`, `cat`, `man`, `wc`
- How to pipe commands together using the `|` operator
- How to redirect output using `<` and `>`
- How to append to the end of a file using `>>`

What we will learn today

In today's lecture, we will learn how to combine these commands in powerful ways:

- How to use shell commands to manipulate and analyze data
- How to write regular expressions
- How to run more complex shell commands such as `grep`, `sort`, `uniq`, `xargs`

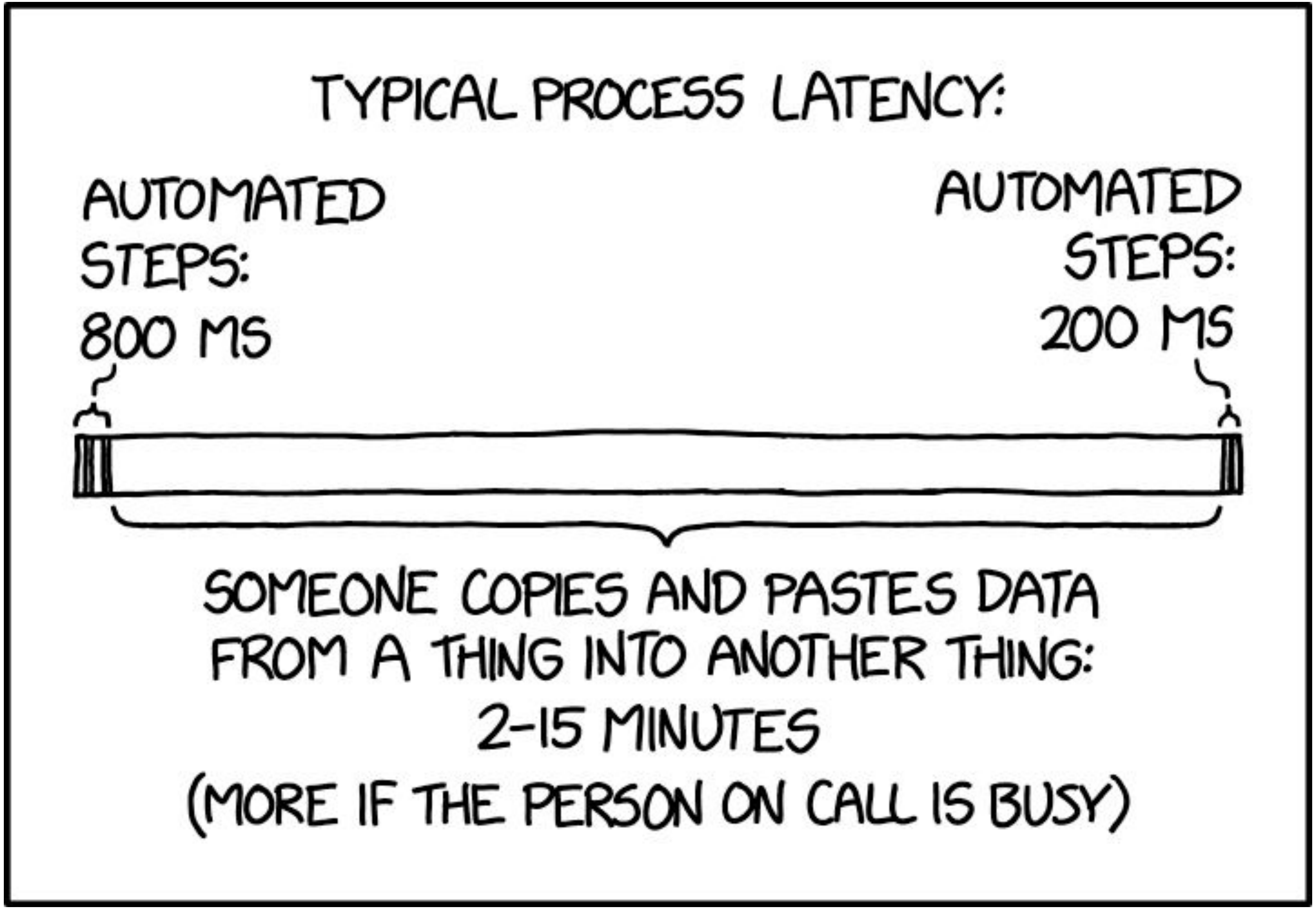
What is Data Wrangling?

Data Wrangling Definition

The basic idea of data wrangling is that you take some raw data and convert or transform it into another form that is more useful.

Ideally, you do this in the most efficient way with the use of a tool 😁

More sources of data and larger amounts of data have made data wrangling increasingly important.


TYPICAL PROCESS LATENCY:
AUTOMATED STEPS: 800 MS
AUTOMATED STEPS: 200 MS
SOMEONE COPIES AND PASTES DATA FROM A THING INTO ANOTHER THING: 2-15 MINUTES
(MORE IF THE PERSON ON CALL IS BUSY)

Source: XKCD

Data Formats

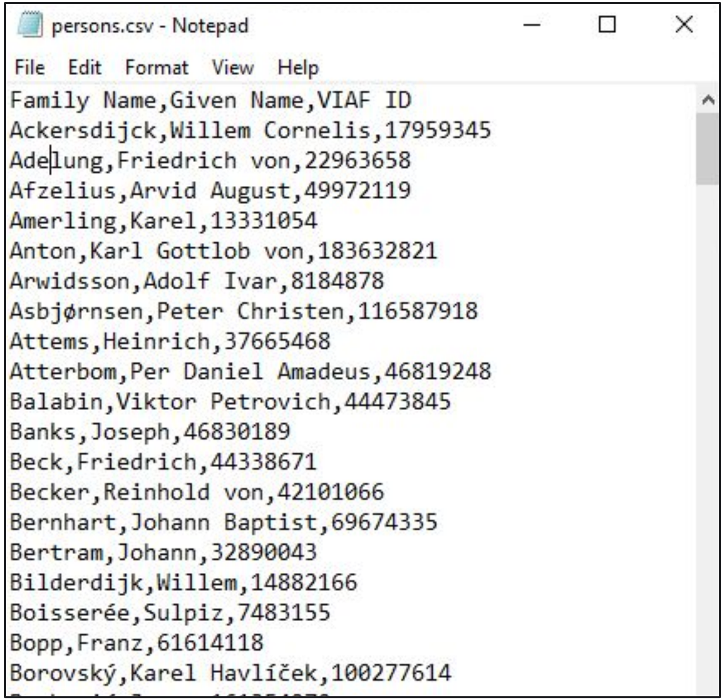
Data wrangling techniques are typically dictated by the data format you are using. Here are five common file formats for storing data:

- CSV
- XML
- HTML
- JSON
- TXT

Data Formats

A **CSV** file is a comma-separated values file where information is separated by commas.

- CSV are plain text files
- Data can be saved in tabular format (meaning a table of rows and columns)
- CSV files are often used to analyze data with spreadsheets

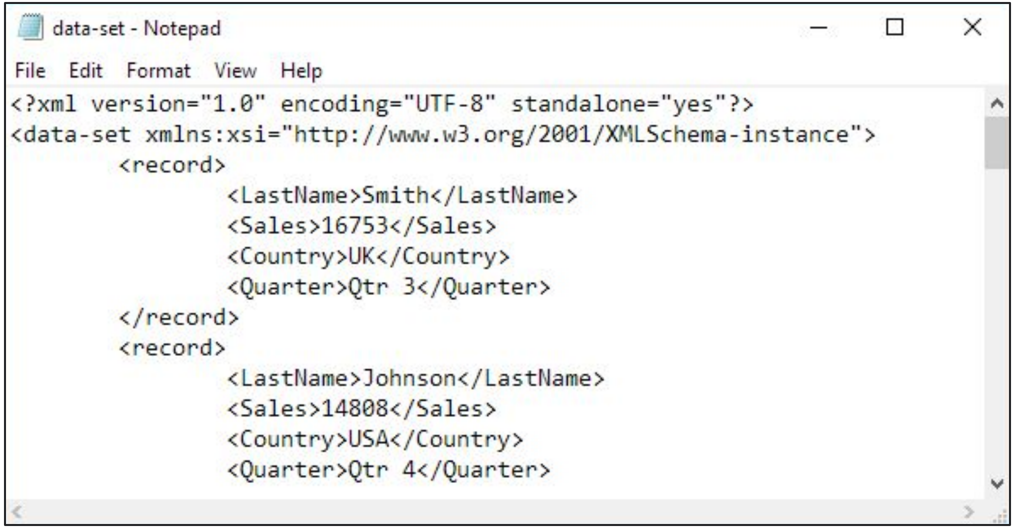


```
Family Name,Given Name,VIAF ID
Ackersdijck,Willem Cornelis,17959345
Adelung,Friedrich von,22963658
Afzelius,Arvid August,49972119
Amerling,Karel,13331054
Anton,Karl Gottlob von,183632821
Arwidsson,Adolf Ivar,8184878
Asbjørnsen,Peter Christen,116587918
Attems,Heinrich,37665468
Atterbom,Per Daniel Amadeus,46819248
Balabin,Viktor Petrovich,44473845
Banks,Joseph,46830189
Beck,Friedrich,44338671
Becker,Reinhold von,42101066
Bernhart,Johann Baptist,69674335
Bertram,Johann,32890043
Bilderdijk,Willem,14882166
Boisserée,Sulpiz,7483155
Bopp,Franz,61614118
Borovský,Karel Havlíček,100277614
```

Data Formats

A **XML** file is an Extensible Markup Language (XML) file that is used to store data in a hierarchical format.

- XML files were created for storing documents in a way that both humans and machines could read.
- XML files consist of tags that define the hierarchy within the document.

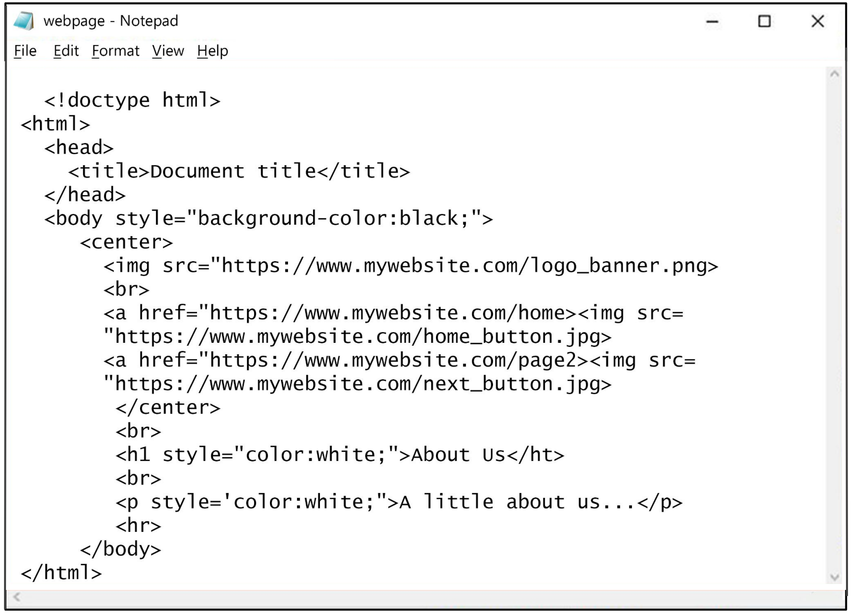


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<data-set xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
        <record>
                <LastName>Smith</LastName>
                <Sales>16753</Sales>
                <Country>UK</Country>
                <Quarter>Qtr 3</Quarter>
        </record>
        <record>
                <LastName>Johnson</LastName>
                <Sales>14808</Sales>
                <Country>USA</Country>
                <Quarter>Qtr 4</Quarter>
```

Data Formats

An **HTML** file is an Hypertext Markup Language file that is used to store data in a hierarchical format, specifically webpages.

- HTML files are similar to XML files
- Key difference between the two is that HTML files must use a predefined set of tags to define hierarchical structure

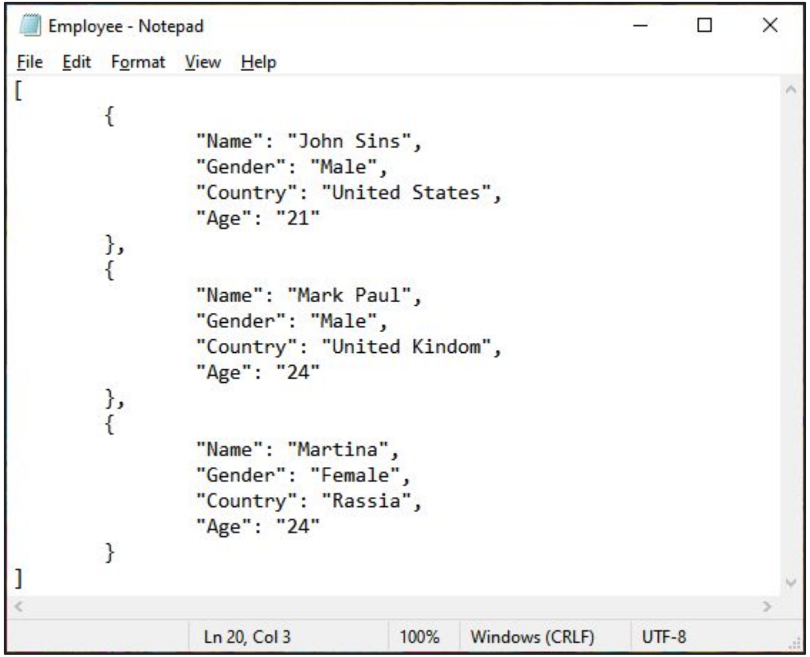


```
  <!doctype html>
<html>
  <head>
    <title>Document title</title>
  </head>
  <body style="background-color:black;">
     <center>
       <img src="https://www.mywebsite.com/logo_banner.png>
       <br>
       <a href="https://www.mywebsite.com/home><img src=
       "https://www.mywebsite.com/home_button.jpg>
       <a href="https://www.mywebsite.com/page2><img src=
       "https://www.mywebsite.com/next_button.jpg>
        </center>
        <br>
        <h1 style="color:white;">About Us</ht>
        <br>
        <p style='color:white;">A little about us...</p>
        <hr>
     </body>
</html>
```

Data Formats

A **JSON** file is a JavaScript Object Notation file that stores structured data in the form of JavaScript objects.

- JSON files are often used for transmitting data in web applications (e.g. sending some data from the server to the client)

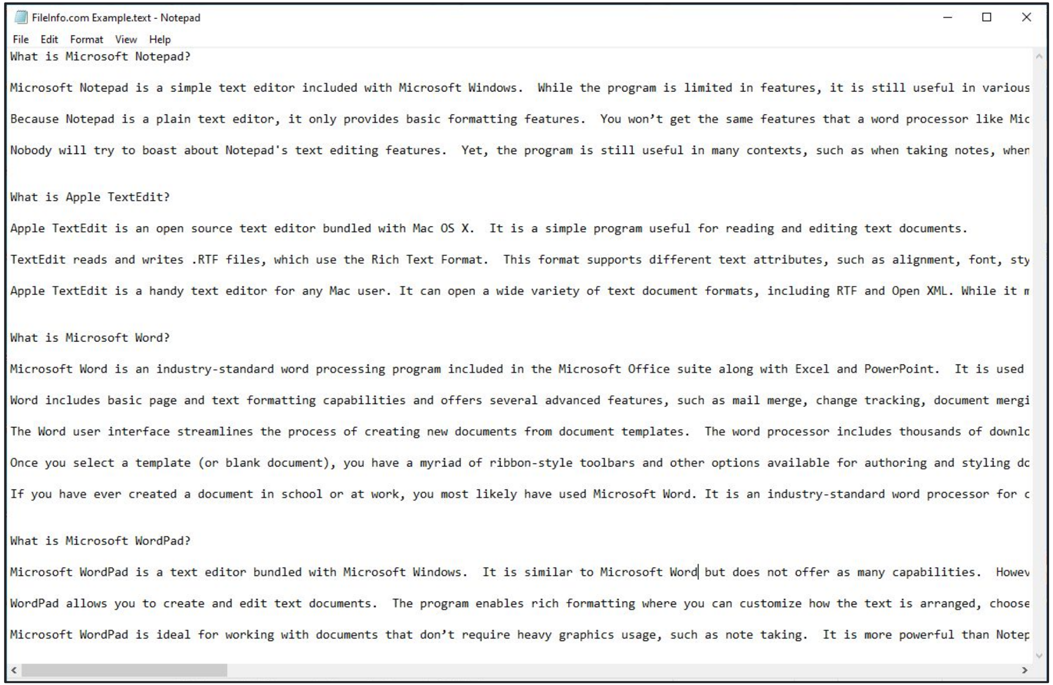


```
[
        {
                "Name": "John Sins",
                "Gender": "Male",
                "Country": "United States",
                "Age": "21"
        },
        {
                "Name": "Mark Paul",
                "Gender": "Male",
                "Country": "United Kindom",
                "Age": "24"
        },
        {
                "Name": "Martina",
                "Gender": "Female",
                "Country": "Rassia",
                "Age": "24"
        }
]
```

Data Formats

A **TXT** file is a plaintext file that stores data in the form of lines.

- TXT files have no special formatting.


FileInfo.com Example.text - Notepad
File Edit Format View Help

What is Microsoft Notepad?

Microsoft Notepad is a simple text editor included with Microsoft Windows. While the program is limited in features, it is still useful in various

Because Notepad is a plain text editor, it only provides basic formatting features. You won’t get the same features that a word processor like Mic

Nobody will try to boast about Notepad's text editing features. Yet, the program is still useful in many contexts, such as when taking notes, when

What is Apple TextEdit?

Apple TextEdit is an open source text editor bundled with Mac OS X. It is a simple program useful for reading and editing text documents.

TextEdit reads and writes .RTF files, which use the Rich Text Format. This format supports different text attributes, such as alignment, font, sty

Apple TextEdit is a handy text editor for any Mac user. It can open a wide variety of text document formats, including RTF and Open XML. While it m

What is Microsoft Word?

Microsoft Word is an industry-standard word processing program included in the Microsoft Office suite along with Excel and PowerPoint. It is used

Word includes basic page and text formatting capabilities and offers several advanced features, such as mail merge, change tracking, document mergi

The Word user interface streamlines the process of creating new documents from document templates. The word processor includes thousands of downlo

Once you select a template (or blank document), you have a myriad of ribbon-style toolbars and other options available for authoring and styling do

If you have ever created a document in school or at work, you most likely have used Microsoft Word. It is an industry-standard word processor for c

What is Microsoft WordPad?

Microsoft WordPad is a text editor bundled with Microsoft Windows. It is similar to Microsoft Word but does not offer as many capabilities. Howev

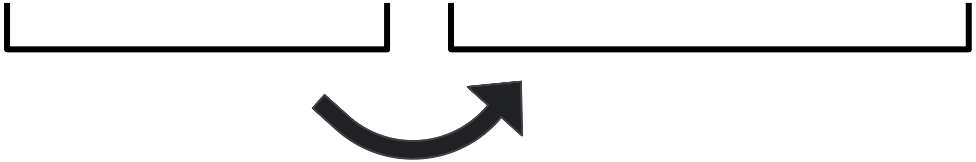
WordPad allows you to create and edit text documents. The program enables rich formatting where you can customize how the text is arranged, choose

Microsoft WordPad is ideal for working with documents that don’t require heavy graphics usage, such as note taking. It is more powerful than Notep

Basic Data Wrangling: `grep`

We’ve already seen a basic form of data wrangling with the `|` operator.

```
ls ~/Documents | grep -i transcript
```



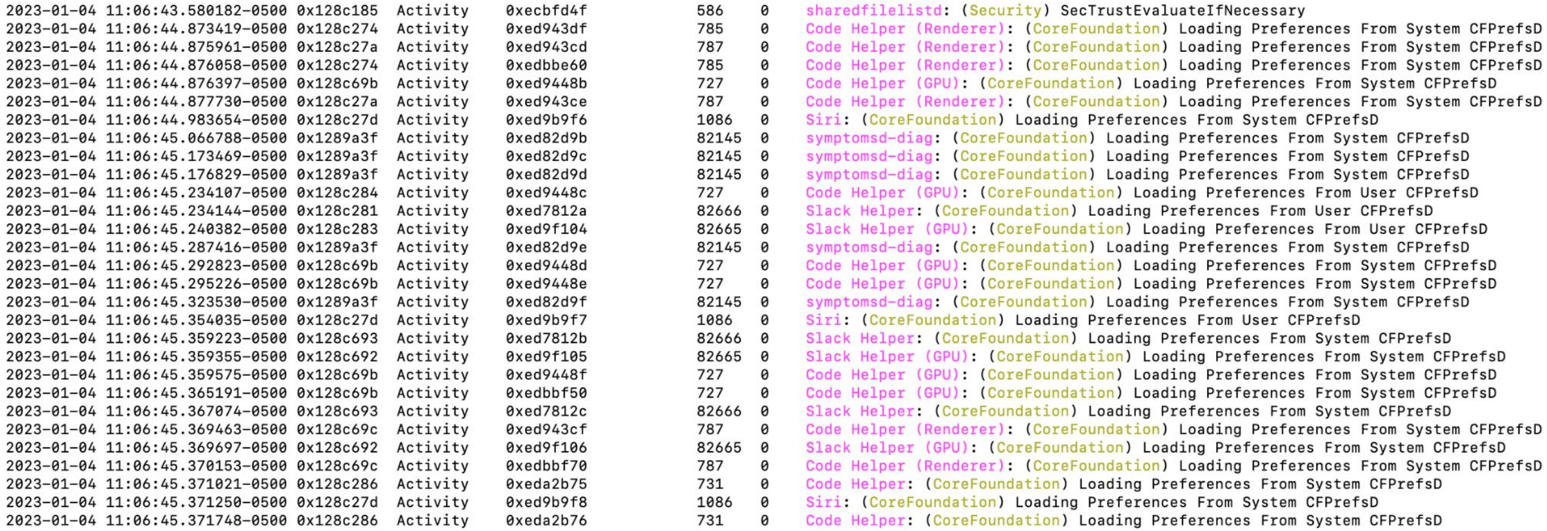
Basic Data Wrangling: `grep`

Another example: system logs!

Basic Data Wrangling: grep

Another example: system logs!

System logs keep a record of operating system events on a machine, thereby producing a *lot* of data.



```
2023-01-04 11:06:43.580182-0500 0x128c185  Activity    0xecbfd4f            586     0     sharedfilelistd: (Security) SecTrustEvaluateIfNecessary
2023-01-04 11:06:44.873419-0500 0x128c274  Activity    0xed943df            785     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:44.875961-0500 0x128c27a  Activity    0xed943cd            787     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:44.876058-0500 0x128c274  Activity    0xedbbe60            785     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:44.876397-0500 0x128c69b  Activity    0xed9448b            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:44.877730-0500 0x128c27a  Activity    0xed943ce            787     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:44.983654-0500 0x128c27d  Activity    0xed9b9f6            1086    0     Siri: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.066788-0500 0x1289a3f  Activity    0xed82d9b            82145   0     symptomsd-diag: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.173469-0500 0x1289a3f  Activity    0xed82d9c            82145   0     symptomsd-diag: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.176829-0500 0x1289a3f  Activity    0xed82d9d            82145   0     symptomsd-diag: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.234107-0500 0x128c284  Activity    0xed9448c            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From User CFPrefsD
2023-01-04 11:06:45.234144-0500 0x128c281  Activity    0xed7812a            82666   0     Slack Helper: (CoreFoundation) Loading Preferences From User CFPrefsD
2023-01-04 11:06:45.240382-0500 0x128c283  Activity    0xed9f104            82665   0     Slack Helper (GPU): (CoreFoundation) Loading Preferences From User CFPrefsD
2023-01-04 11:06:45.287416-0500 0x1289a3f  Activity    0xed82d9e            82145   0     symptomsd-diag: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.292823-0500 0x128c69b  Activity    0xed9448d            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.295226-0500 0x128c69b  Activity    0xed9448e            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.323530-0500 0x1289a3f  Activity    0xed82d9f            82145   0     symptomsd-diag: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.354035-0500 0x128c27d  Activity    0xed9b9f7            1086    0     Siri: (CoreFoundation) Loading Preferences From User CFPrefsD
2023-01-04 11:06:45.359223-0500 0x128c693  Activity    0xed7812b            82666   0     Slack Helper: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.359355-0500 0x128c692  Activity    0xed9f105            82665   0     Slack Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.359575-0500 0x128c69b  Activity    0xed9448f            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.365191-0500 0x128c69b  Activity    0xedbbf50            727     0     Code Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.367074-0500 0x128c693  Activity    0xed7812c            82666   0     Slack Helper: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.369463-0500 0x128c69c  Activity    0xed943cf            787     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.369697-0500 0x128c692  Activity    0xed9f106            82665   0     Slack Helper (GPU): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.370153-0500 0x128c69c  Activity    0xedbbf70            787     0     Code Helper (Renderer): (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.371021-0500 0x128c286  Activity    0xeda2b75            731     0     Code Helper: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.371250-0500 0x128c27d  Activity    0xed9b9f8            1086    0     Siri: (CoreFoundation) Loading Preferences From System CFPrefsD
2023-01-04 11:06:45.371748-0500 0x128c286  Activity    0xeda2b76            731     0     Code Helper: (CoreFoundation) Loading Preferences From System CFPrefsD
```

Basic Data Wrangling: grep

Another example: system logs!

System logs keep a record of operating system events on a machine, thereby producing a *lot* of data.

```
log show | grep -i Chrome
```

(macOS)

```
journalctl | grep -i Chrome
```

(Linux)

```
wevutil gp Microsoft-Windows-Eventlog /ge:true | grep -i Chrome
```

(Windows)

Basic Data Wrangling: grep

For this next example, I will be using a system log on a CS45 honeypot. If you want to follow along with the data, you can download the data using:

```
curl -Lo honeypot_log.txt
https://cs45.stanford.edu/res/lec3/honeypot_log.txt
```

Basic Data Wrangling: grep

Another useful command is the `history` command, which is used to view previously executed commands:

```
adrazen@ayelet-computer ~ % history
1030  ls
1031  ssh adrazen@192.9.152.85 journalctl >
honeypot_log.txt
1032  cat honeypot_log.txt
1033  scp honeypot_log.txt
adrazen@myth.stanford.edu:~/cs45/root/WWW/lectures
```

Basic Data Wrangling: grep

We can even search for system log events on a remote server. Let’s look for everything related to ssh on a CS45 honeypot:

```
ssh adrazen@192.9.152.85 journalctl | grep sshd
```

Basic Data Wrangling: `grep`

We can even search for system log events on a remote server. Let’s look for everything related to `ssh` on a CS45 honeypot.

Let’s look for times when users were disconnected.

```
ssh adrazen@192.9.152.85 journalctl | grep sshd | grep
“Disconnected from”
```

Basic Data Wrangling: grep

We should make sure to avoid sending unnecessary data across the machines. Let’s run the pipeline on the remote machine by adding quotes:

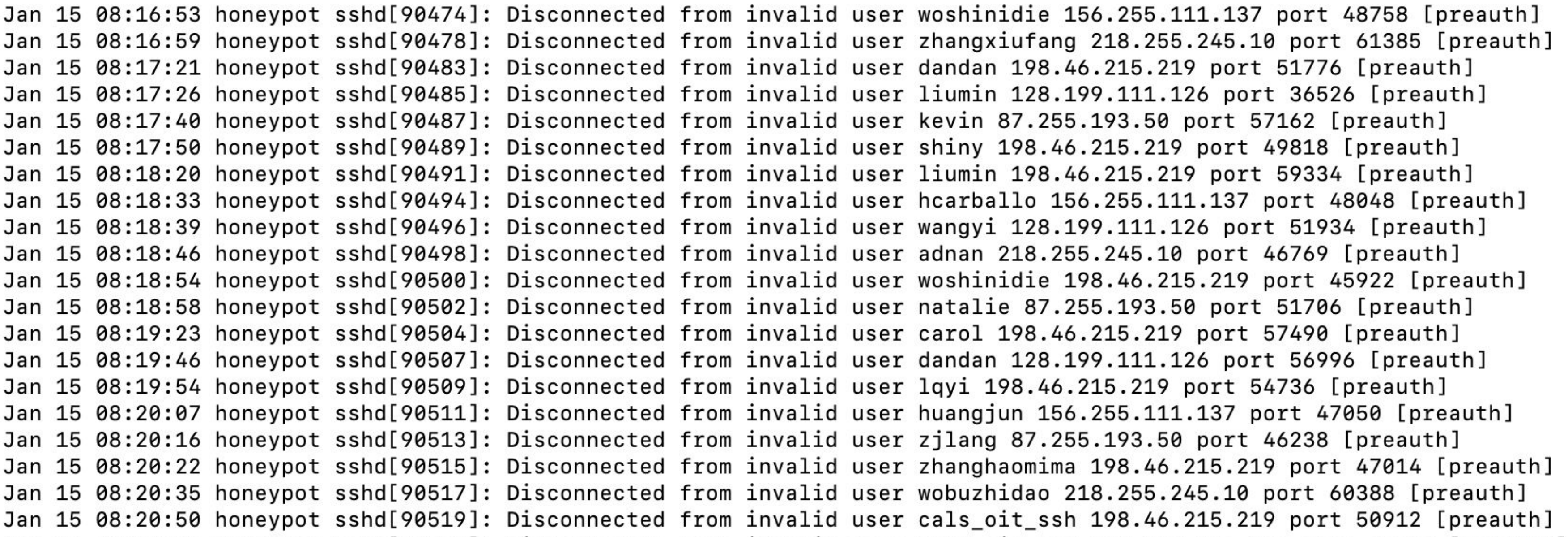
```
ssh adrazen@192.9.152.85 'journalctl | grep sshd | grep
"Disconnected from"'
```

Basic Data Wrangling: sed

Now maybe we are interested in extracting the usernames for the users who were disconnected.

Basic Data Wrangling: sed

Let's say we are interested in extracting the usernames for the users who were disconnected.



```
Jan 15 08:16:53 honeypot sshd[90474]: Disconnected from invalid user woshinidie 156.255.111.137 port 48758 [preauth]
Jan 15 08:16:59 honeypot sshd[90478]: Disconnected from invalid user zhangxiufang 218.255.245.10 port 61385 [preauth]
Jan 15 08:17:21 honeypot sshd[90483]: Disconnected from invalid user dandan 198.46.215.219 port 51776 [preauth]
Jan 15 08:17:26 honeypot sshd[90485]: Disconnected from invalid user liumin 128.199.111.126 port 36526 [preauth]
Jan 15 08:17:40 honeypot sshd[90487]: Disconnected from invalid user kevin 87.255.193.50 port 57162 [preauth]
Jan 15 08:17:50 honeypot sshd[90489]: Disconnected from invalid user shiny 198.46.215.219 port 49818 [preauth]
Jan 15 08:18:20 honeypot sshd[90491]: Disconnected from invalid user liumin 198.46.215.219 port 59334 [preauth]
Jan 15 08:18:33 honeypot sshd[90494]: Disconnected from invalid user hcarballo 156.255.111.137 port 48048 [preauth]
Jan 15 08:18:39 honeypot sshd[90496]: Disconnected from invalid user wangyi 128.199.111.126 port 51934 [preauth]
Jan 15 08:18:46 honeypot sshd[90498]: Disconnected from invalid user adnan 218.255.245.10 port 46769 [preauth]
Jan 15 08:18:54 honeypot sshd[90500]: Disconnected from invalid user woshinidie 198.46.215.219 port 45922 [preauth]
Jan 15 08:18:58 honeypot sshd[90502]: Disconnected from invalid user natalie 87.255.193.50 port 51706 [preauth]
Jan 15 08:19:23 honeypot sshd[90504]: Disconnected from invalid user carol 198.46.215.219 port 57490 [preauth]
Jan 15 08:19:46 honeypot sshd[90507]: Disconnected from invalid user dandan 128.199.111.126 port 56996 [preauth]
Jan 15 08:19:54 honeypot sshd[90509]: Disconnected from invalid user lqyi 198.46.215.219 port 54736 [preauth]
Jan 15 08:20:07 honeypot sshd[90511]: Disconnected from invalid user huangjun 156.255.111.137 port 47050 [preauth]
Jan 15 08:20:16 honeypot sshd[90513]: Disconnected from invalid user zjlang 87.255.193.50 port 46238 [preauth]
Jan 15 08:20:22 honeypot sshd[90515]: Disconnected from invalid user zhanghaomima 198.46.215.219 port 47014 [preauth]
Jan 15 08:20:35 honeypot sshd[90517]: Disconnected from invalid user wobuzhidao 218.255.245.10 port 60388 [preauth]
Jan 15 08:20:50 honeypot sshd[90519]: Disconnected from invalid user cals_oit_ssh 198.46.215.219 port 50912 [preauth]
```

Basic Data Wrangling: `sed`

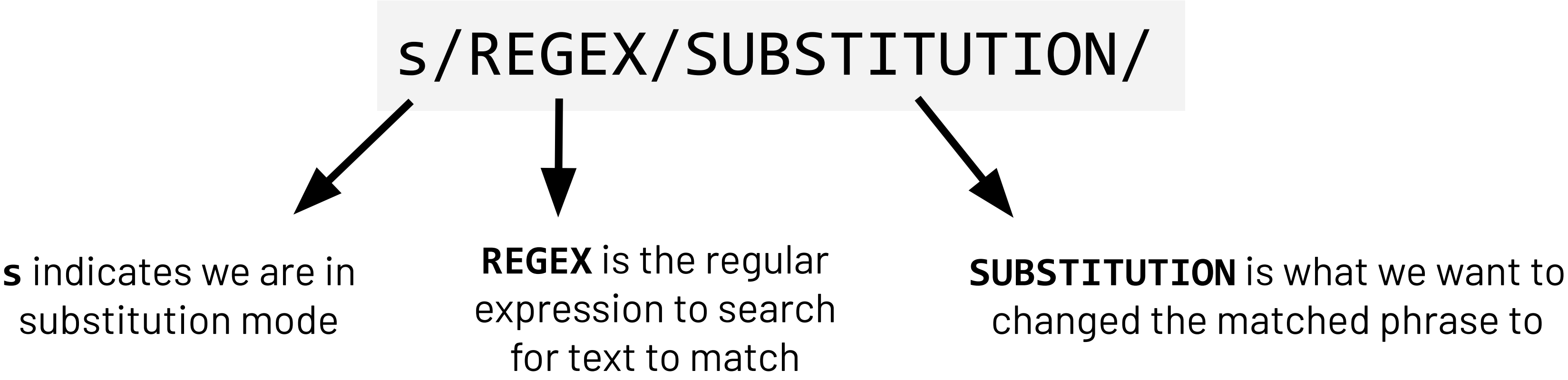
Now maybe we are interested in extracting the usernames for the users who were disconnected.

We can use a tool called **`sed`** to help sift through our data.

> `sed` is a stream editor that is built into Unix.
>
> It can be used for searching a file, adding lines to a file, or substituting text in a file.

Basic Data Wrangling: sed

Let's use sed for substitution.



```
s/REGEX/SUBSTITUTION/
```

s indicates we are in substitution mode

REGEX is the regular expression to search for text to match

SUBSTITUTION is what we want to changed the matched phrase to

Basic Data Wrangling: sed

Original File:

```
Courses taken in AY21-22 will be counted towards your major.
You must take the course in AY21-22
```

Basic Data Wrangling: sed

Original File:

```
Courses taken in AY21-22 will be counted towards your major.
You must take the course in AY21-22
```

Command:

```
sed 's/AY21-22/AY22-23/' file.txt
```

Text to match

Replacement text

Basic Data Wrangling: sed

Original File:

```
Courses taken in AY21-22 will be counted towards your major.
You must take the course in AY21-22
```

Command:

```
sed 's/AY21-22/AY22-23/' file.txt
```

Text to match

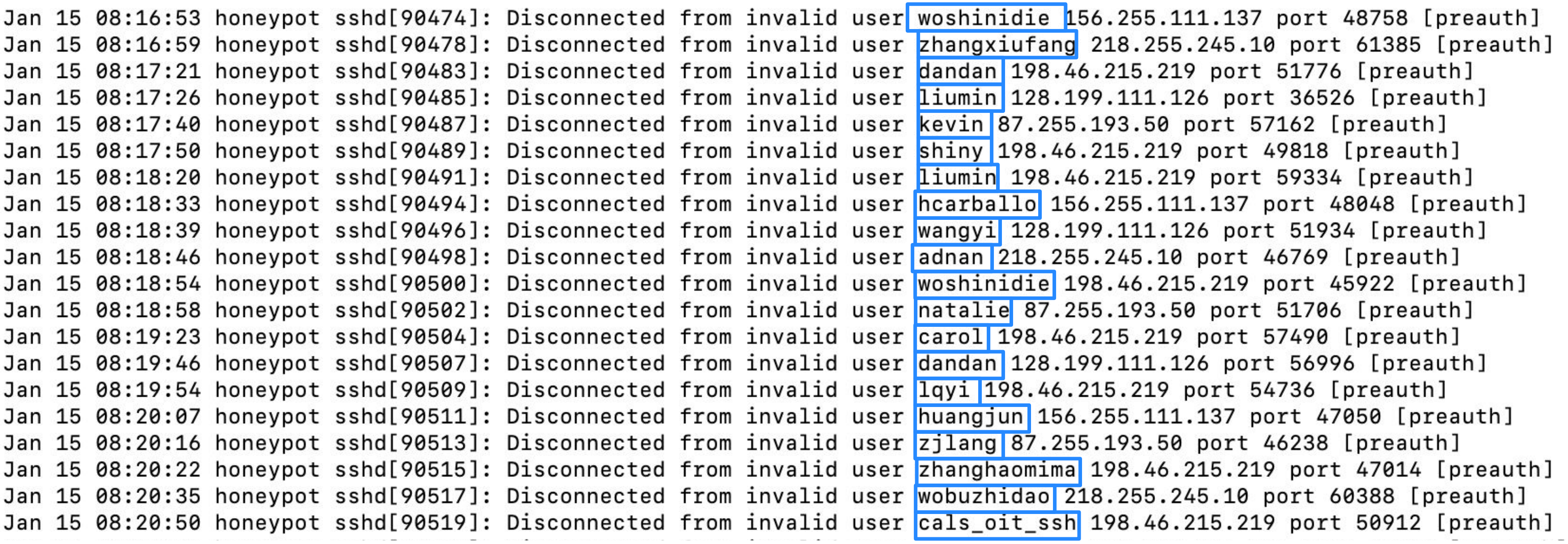
Replacement text

After sed:

```
Courses taken in AY22-23 will be counted towards your major.
You must take the course in AY22-23
```

Basic Data Wrangling: sed

Let's say we interested in extracting the usernames for the users who were disconnected.



```
Jan 15 08:16:53 honeypot sshd[90474]: Disconnected from invalid user woshinidie 156.255.111.137 port 48758 [preauth]
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Jan 15 08:17:21 honeypot sshd[90483]: Disconnected from invalid user dandan 198.46.215.219 port 51776 [preauth]
Jan 15 08:17:26 honeypot sshd[90485]: Disconnected from invalid user liumin 128.199.111.126 port 36526 [preauth]
Jan 15 08:17:40 honeypot sshd[90487]: Disconnected from invalid user kevin 87.255.193.50 port 57162 [preauth]
Jan 15 08:17:50 honeypot sshd[90489]: Disconnected from invalid user shiny 198.46.215.219 port 49818 [preauth]
Jan 15 08:18:20 honeypot sshd[90491]: Disconnected from invalid user liumin 198.46.215.219 port 59334 [preauth]
Jan 15 08:18:33 honeypot sshd[90494]: Disconnected from invalid user hcarballo 156.255.111.137 port 48048 [preauth]
Jan 15 08:18:39 honeypot sshd[90496]: Disconnected from invalid user wangyi 128.199.111.126 port 51934 [preauth]
Jan 15 08:18:46 honeypot sshd[90498]: Disconnected from invalid user adnan 218.255.245.10 port 46769 [preauth]
Jan 15 08:18:54 honeypot sshd[90500]: Disconnected from invalid user woshinidie 198.46.215.219 port 45922 [preauth]
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Jan 15 08:19:23 honeypot sshd[90504]: Disconnected from invalid user carol 198.46.215.219 port 57490 [preauth]
Jan 15 08:19:46 honeypot sshd[90507]: Disconnected from invalid user dandan 128.199.111.126 port 56996 [preauth]
Jan 15 08:19:54 honeypot sshd[90509]: Disconnected from invalid user lqyi 198.46.215.219 port 54736 [preauth]
Jan 15 08:20:07 honeypot sshd[90511]: Disconnected from invalid user huangjun 156.255.111.137 port 47050 [preauth]
Jan 15 08:20:16 honeypot sshd[90513]: Disconnected from invalid user zjlang 87.255.193.50 port 46238 [preauth]
Jan 15 08:20:22 honeypot sshd[90515]: Disconnected from invalid user zhanghaomima 198.46.215.219 port 47014 [preauth]
Jan 15 08:20:35 honeypot sshd[90517]: Disconnected from invalid user wobuzhidao 218.255.245.10 port 60388 [preauth]
Jan 15 08:20:50 honeypot sshd[90519]: Disconnected from invalid user cals_oit_ssh 198.46.215.219 port 50912 [preauth]
```

Regular Expressions

What is a regular expression?

> A *regular expression* (also called a regex) is a set of characters that specifies a search pattern.

Most ASCII characters carry their normal meaning but some characters have special matching behavior.

There is some variation between different implementations of regular expressions.

Regular Expressions

First, there are **groups** of characters. These specify *which* characters we are interested in:

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`[abc]` means any of the characters included inside the square brackets (in this case a, b or c)

Regular Expressions

First, there are **groups** of characters. These specify *which* characters we are interested in:

`.` means any single character (except the newline character)

`[abc]` means any of the characters included inside the square brackets (in this case a, b or c)

`[a-z]` means any character in the range a-z

Regular Expressions

First, there are **groups** of characters. These specify *which* characters we are interested in:

`.` means any single character (except the newline character)

`[abc]` means any of the characters included inside the square brackets (in this case a, b or c)

`[a-z]` means any character in the range a-z

`(a|b)` means either a or b

Regular Expressions

Next, we have **quantifiers**. These specify *how many* characters we are interested in:

Regular Expressions

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Regular Expressions

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`*` means we want 0 or more characters of the specified kind

`+` means we want 1 or more characters of the specified kind

Regular Expressions

Next, we have **quantifiers**. These specify *how many* characters we are interested in:

`*` means we want 0 or more characters of the specified kind

`+` means we want 1 or more characters of the specified kind

`?` means we want exactly 0 or 1 characters of the specified kind

Regular Expressions

Next, we have **quantifiers**. These specify *how many* characters we are interested in:

`*` means we want 0 or more characters of the specified kind

`+` means we want 1 or more characters of the specified kind

`?` means we want exactly 0 or 1 characters of the specified kind

`{X}` means we want exactly X characters of the specified kind

Regular Expressions

Finally, we have **anchors**. These specify *specific starting or stopping* conditions we are interested in:

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`^` specifies the start of the line

Regular Expressions

Finally, we have **anchors**. These specify *specific starting or stopping* conditions we are interested in:

- `^` specifies the start of the line
- `$` specifies the end of the line

HOW TO REGEX
STEP 1: OPEN YOUR FAVORITE EDITOR
@GARABATOKID
STEP 2: LET YOUR CAT PLAY ON YOUR KEYBOARD
/^([A-Z0-9_\.-

Source: @garabatokid

RegEx Applications

Regular expressions are really useful in all kinds of applications!

You can use regular expressions inside of applications such as Excel and Google Sheets that support data processing.

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Regular Expressions

Time for examples!

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Regular Expressions

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Regular Expressions

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1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters? Any character A-Z, a-z,0-9, ., _, %, +, -

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters? Any character A-Z, a-z,0-9, ., _, %, +, -

```
[A-Za-z0-9._%+-]
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters? Any character A-Z, a-z,0-9, ., _, %, +, -

```
[A-Za-z0-9._%+-]
```

How many of them?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters? Any character A-Z, a-z,0-9, ., _, %, +, -

```
[A-Za-z0-9._%+-]
```

How many of them? As many as you want... (at least 1!)

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

Which characters? Any character A-Z, a-z,0-9, ., _, %, +, -

```
[A-Za-z0-9._%+-]
```

How many of them? As many as you want... (at least 1!)

```
[A-Za-z0-9._%+-]+
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

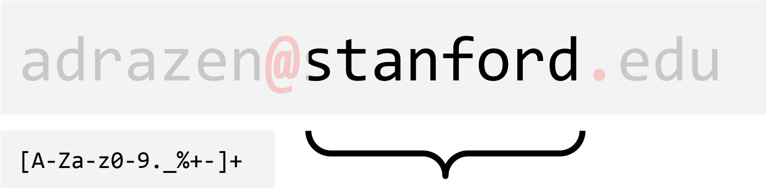
```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



```
adrazen@stanford.edu
```

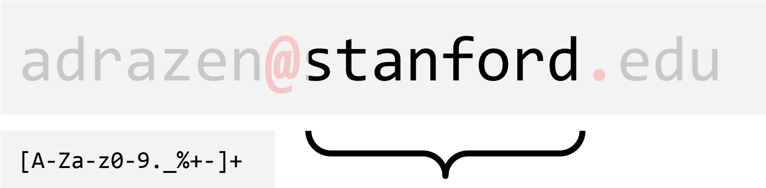
```
[A-Za-z0-9._%+-]+
```

Which characters?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



```
adrazen@stanford.edu
```

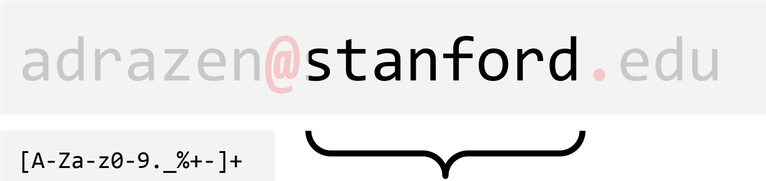
```
[A-Za-z0-9._%+-]+
```

Which characters? Any character A-Z, a-z,0-9, ., -

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



adrazen@stanford.edu

```
[A-Za-z0-9._%+-]+
```

Which characters? Any character A-Z, a-z,0-9, ., -

```
[A-Za-z0-9.-]
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

Which characters? Any character A-Z, a-z,0-9, ., -

```
[A-Za-z0-9.-]
```

How many of them?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

Which characters? Any character A-Z, a-z,0-9, ., -

```
[A-Za-z0-9.-]
```

How many of them? As many as you want... (at least 1!)

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

Which characters? Any character A-Z, a-z,0-9, ., -

```
[A-Za-z0-9.-]
```

How many of them? As many as you want... (at least 1!)

```
[A-Za-z0-9.-]+
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

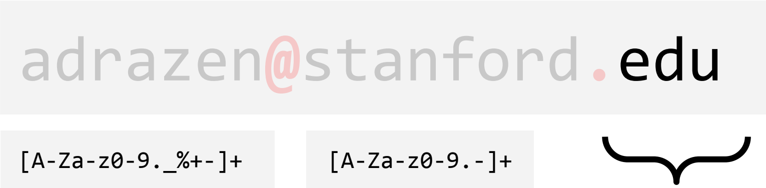
```
[A-Za-z0-9._%+-]+
```

```
[A-Za-z0-9.-]+
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



adrazen@stanford.edu

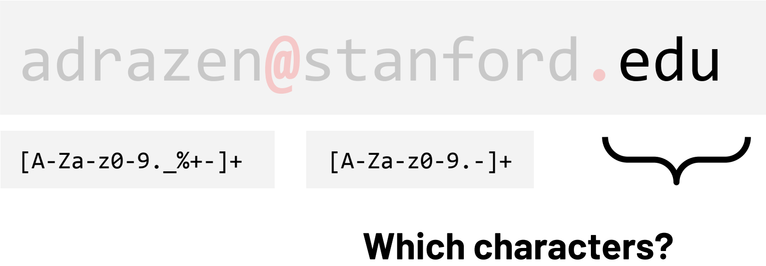
`[A-Za-z0-9._%+-]+`

`[A-Za-z0-9.-]+`

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

```
[A-Za-z0-9.-]+
```

Which characters?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

`[A-Za-z0-9._%+-]+`

`[A-Za-z0-9.-]+`

Which characters? Any character A-Z, a-z

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

`[A-Za-z0-9._%+-]+`   `[A-Za-z0-9.-]+`

Which characters?

Any character A-Z, a-z

```
[A-Za-z]
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

```
[A-Za-z0-9.-]+
```

Which characters? Any character A-Z, a-z

```
[A-Za-z]
```

How many of them?

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

`[A-Za-z0-9._%+-]+` `[A-Za-z0-9.-]+`

Which characters? Any character A-Z, a-z

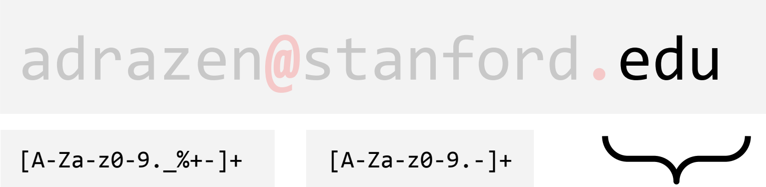
`[A-Za-z]`

How many of them? At least 2

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses



`adrazen@stanford.edu`

`[A-Za-z0-9._%+-]+` `[A-Za-z0-9.-]+`

Which characters? Any character A-Z, a-z

`[A-Za-z]`

How many of them? At least 2

`[A-Za-z]{2,}`

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+    [A-Za-z0-9.-]+    [A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+
```

```
[A-Za-z0-9.-]+
```

```
[A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+   @   [A-Za-z0-9.-]+   .   [A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+ @ [A-Za-z0-9.-]+ \. [A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+  @  [A-Za-z0-9.-]+  \.  [A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
adrazen@stanford.edu
```

```
[A-Za-z0-9._%+-]+@[A-Za-z0-9.-]+\.[A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
[A-Za-z0-9._%+-]+@[A-Za-z0-9.-]+\.[A-Za-z]{2,}
```

Regular Expressions

Time for examples!

1. Write a regular expression to match all email addresses

```
[A-Za-z0-9._%+-]+@[A-Za-z0-9.-]+\.[A-Za-z]{2,}
```

Technically, this RegEx only matches some 99% of email addresses. Here is the fully RFC compliant RegEx for all emails... 😱

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user root 205.185.126.149 port 44302 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user root 205.185.126.149 port 44302 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
mongodb
```

```
13.87.204.143 port 50660 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
mongodb
```

```
13.87.204.143 port 50660 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```

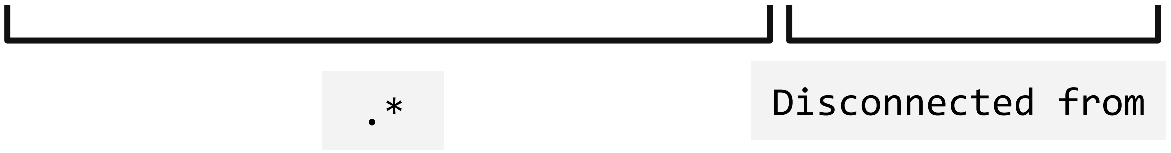
```
.*
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```



```
.*
```

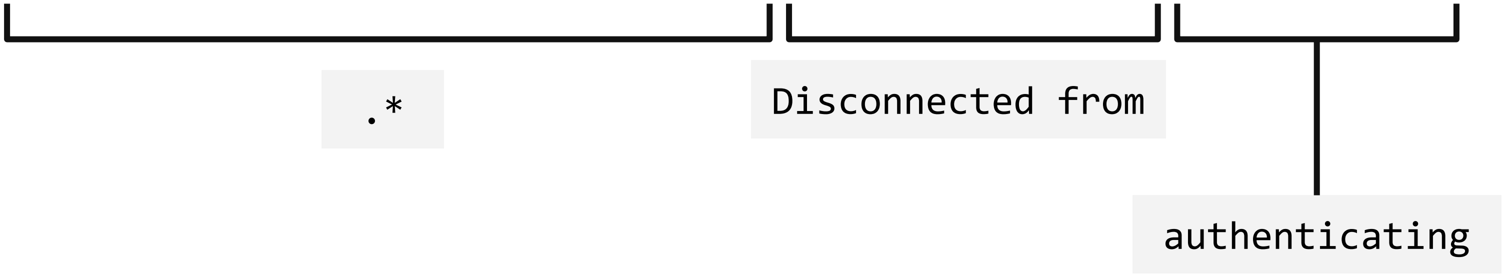
```
Disconnected from
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```



`.*`

`Disconnected from`

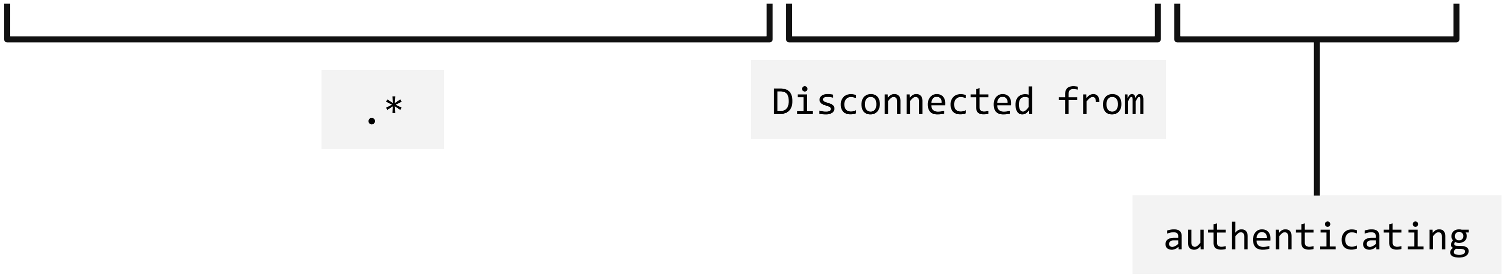
`authenticating`

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```



```
.*
```

```
Disconnected from
```

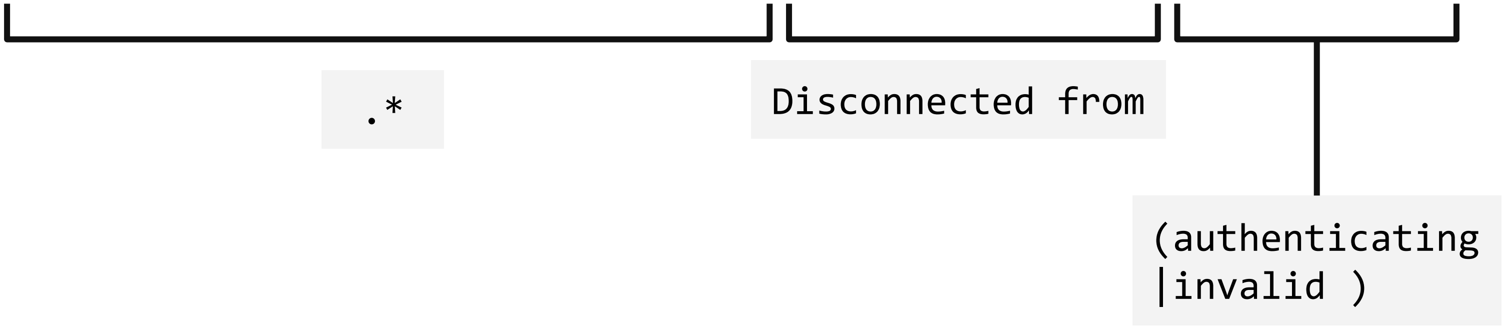
```
authenticating
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```



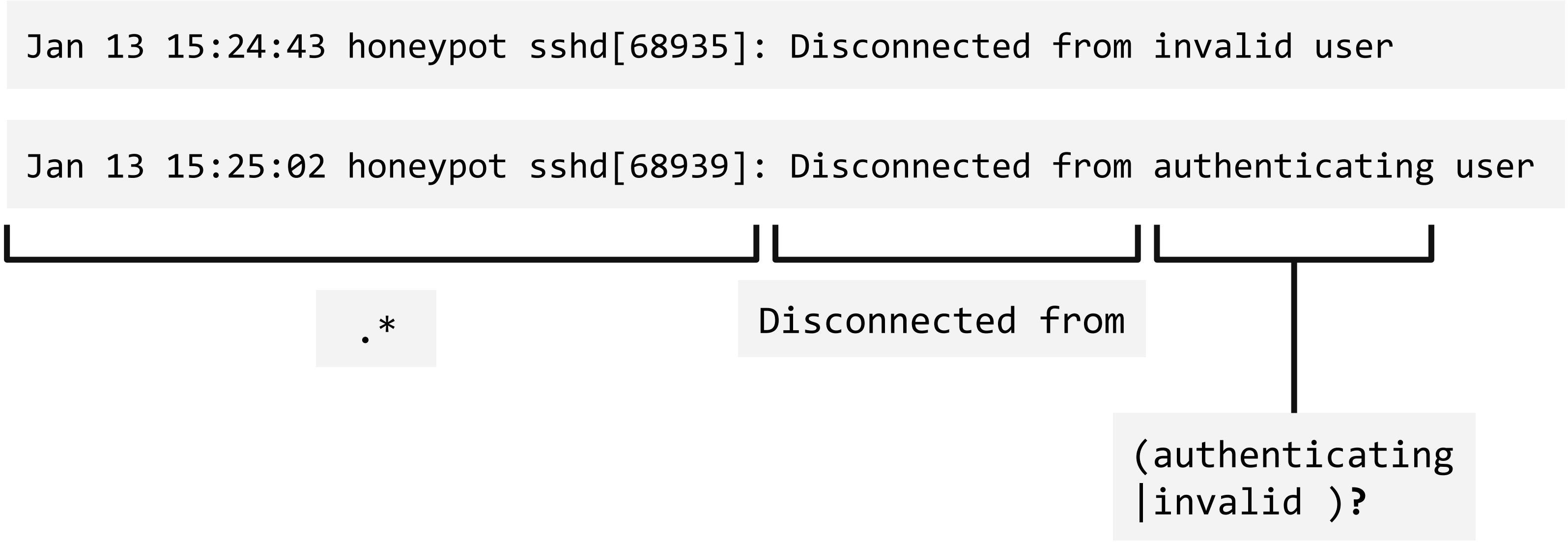
```
.*
```

```
Disconnected from
```

```
(authenticating |invalid )
```

Regular Expressions

2. Write a regular expression to parse username from log line



```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```

```
.*
```

```
Disconnected from
```

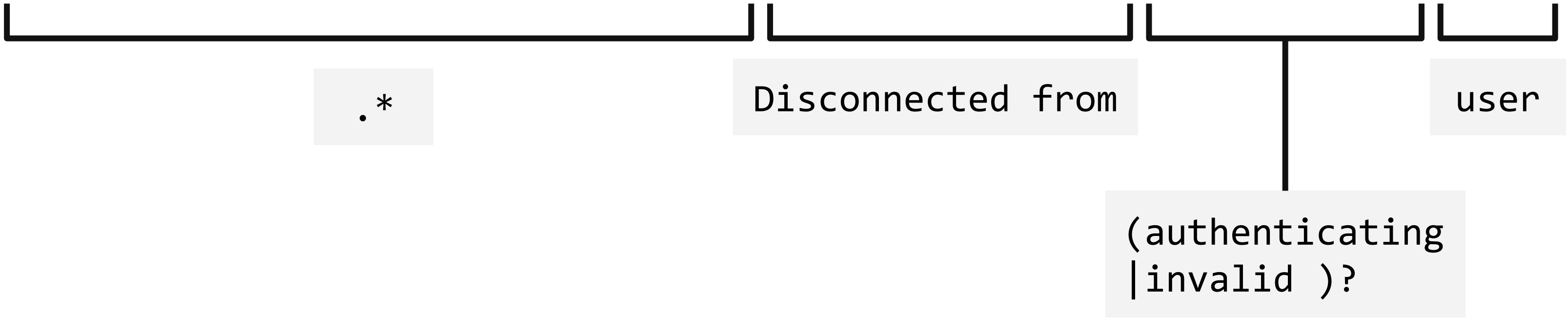
```
(authenticating
|invalid )?
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```



```
.*
```

```
Disconnected from
```

```
(authenticating
|invalid )?
```

```
user
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user
```

```
.* Disconnected from (authenticating |invalid )?user
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user  mongodb  13.87.204.143 port 50660 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
mongodb
```

```
root
```

Regular Expressions

2. Write a regular expression to parse username from log line

`mongodb`

`root`

␣

`.*`

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
mongodb
```

```
13.87.204.143 port 50660 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```

Regular Expressions

2. Write a regular expression to parse username from log line

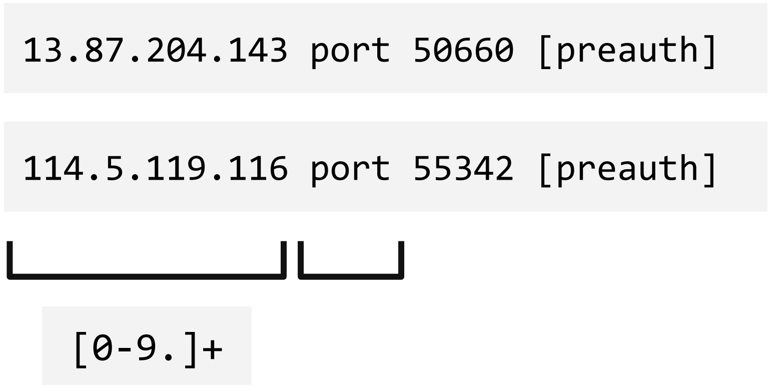
```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```

```
[0-9.]+
```

Regular Expressions

2. Write a regular expression to parse username from log line



```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```

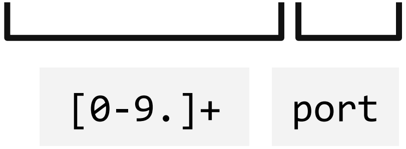
```
[0-9.]+
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

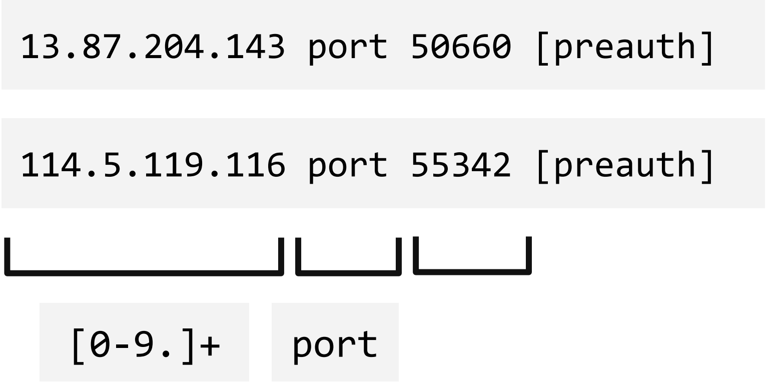
```
114.5.119.116 port 55342 [preauth]
```



`[0-9.]+` `port`

Regular Expressions

2. Write a regular expression to parse username from log line



```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```

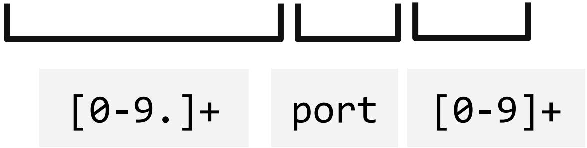
`[0-9.]+` `port`

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```



```
[0-9.]+
```

```
port
```

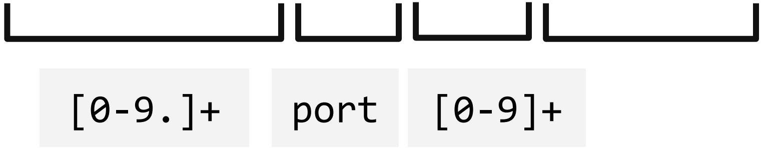
```
[0-9]+
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```



`[0-9.]+`

`port`

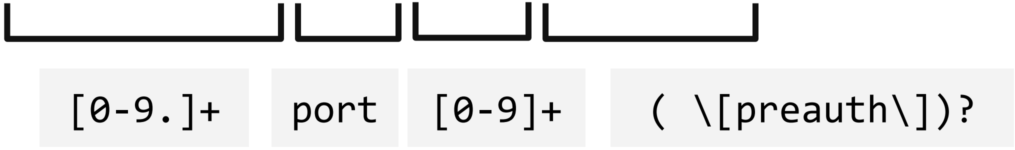
`[0-9]+`

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

```
114.5.119.116 port 55342 [preauth]
```



```
[0-9.]+   port   [0-9]+   ( \[preauth\])?
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
13.87.204.143 port 50660 [preauth]
```

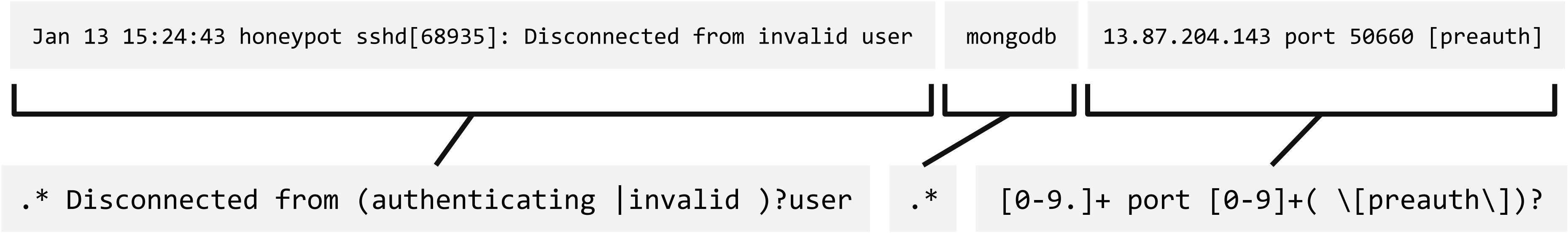
```
114.5.119.116 port 55342 [preauth]
```

```
[0-9.]+ port [0-9]+( \[preauth\])?
```

Regular Expressions

2. Write a regular expression to parse username from log line

```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```



```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user
```

```
mongodb
```

```
13.87.204.143 port 50660 [preauth]
```

```
.* Disconnected from (authenticating |invalid )?user
```

```
.*
```

```
[0-9.]+ port [0-9]+( \[preauth\])?
```

Regular Expressions

2. Write a regular expression to parse username from log line

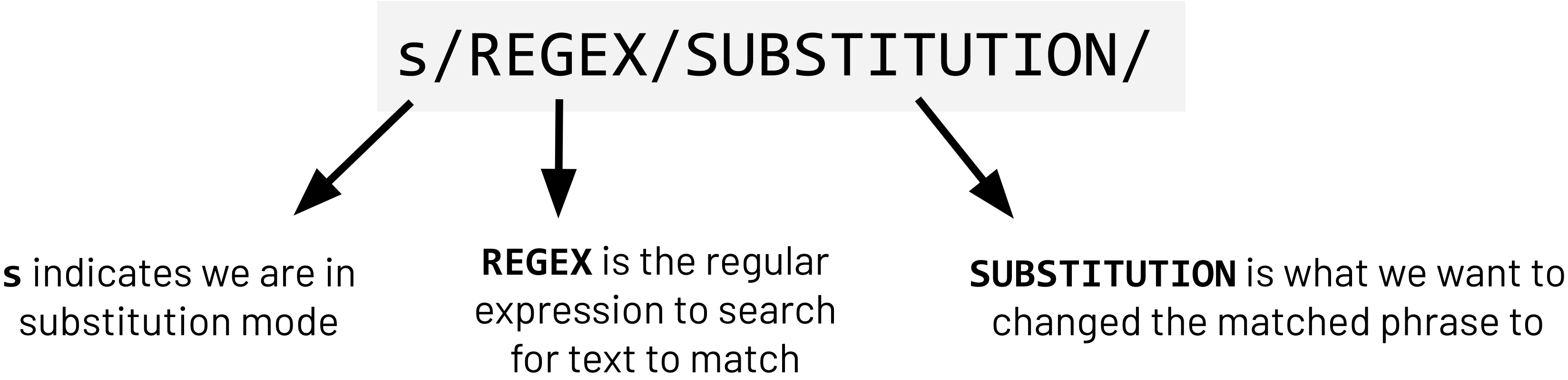
```
Jan 13 15:24:43 honeypot sshd[68935]: Disconnected from invalid user mongodb 13.87.204.143 port 50660 [preauth]
```

```
Jan 13 15:25:02 honeypot sshd[68939]: Disconnected from authenticating user root 205.185.126.149 port 44302 [preauth]
```

```
.* Disconnected from (authenticating |invalid )?user .* [0-9.]+ port [0-9]+( \[preauth\])?
```

Regular Expressions

Let's use `sed` for substitution.



```
s/REGEX/SUBSTITUTION/
```

`s` indicates we are in substitution mode

`REGEX` is the regular expression to search for text to match

`SUBSTITUTION` is what we want to changed the matched phrase to

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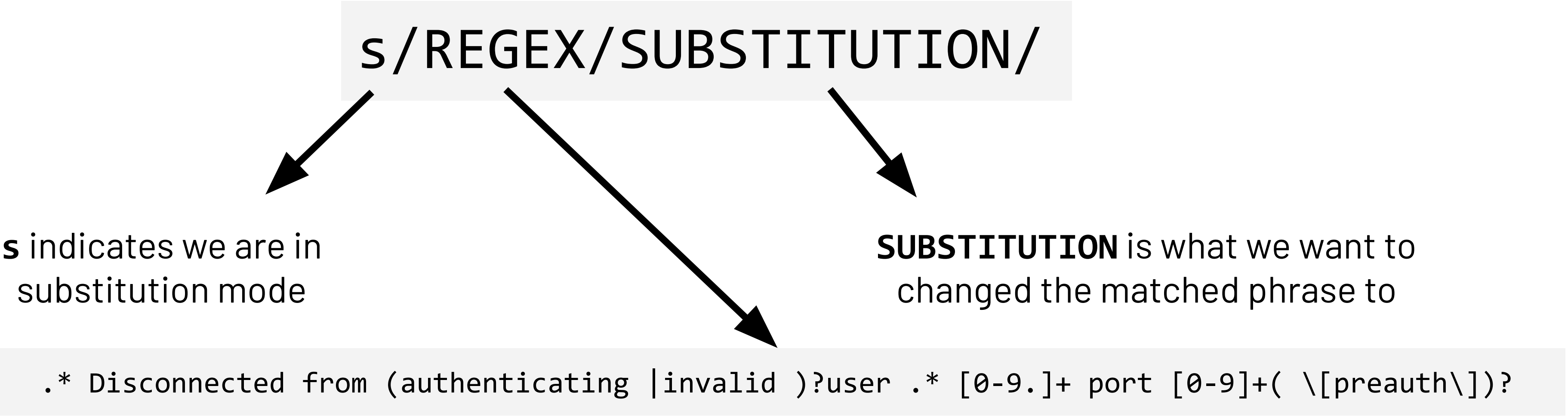

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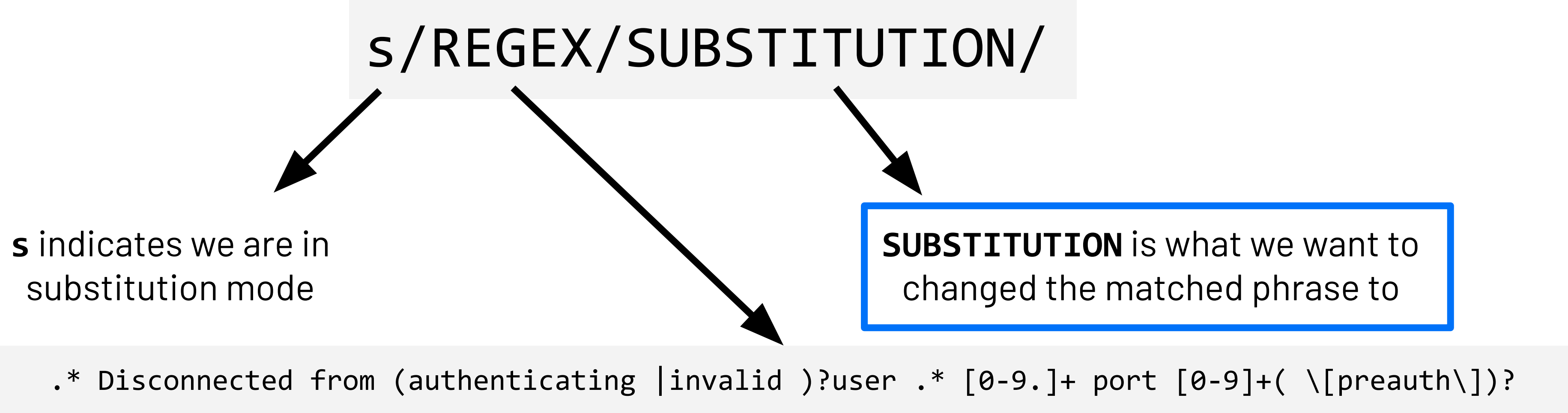

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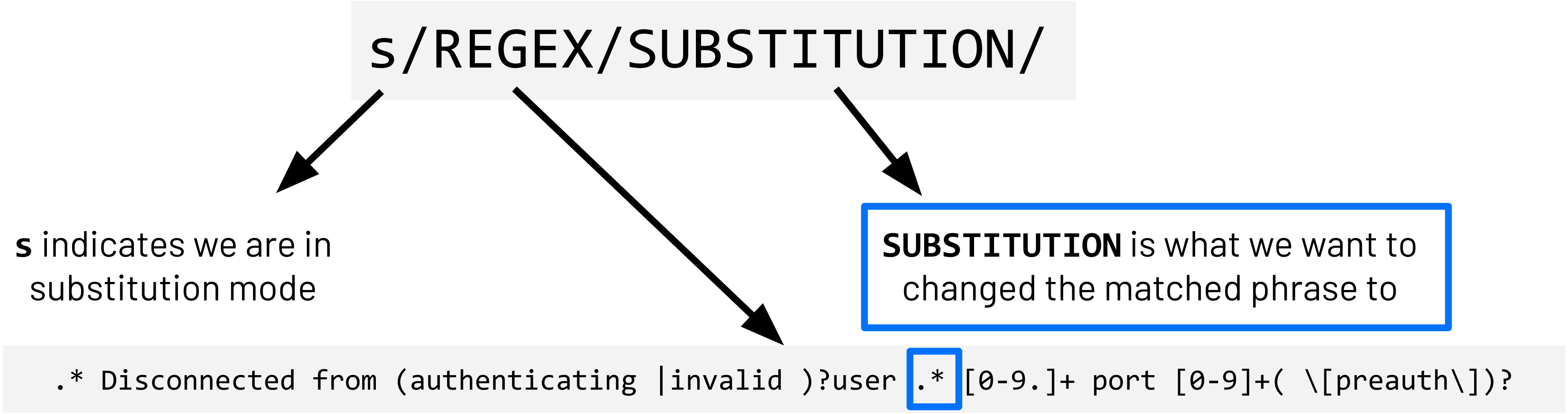

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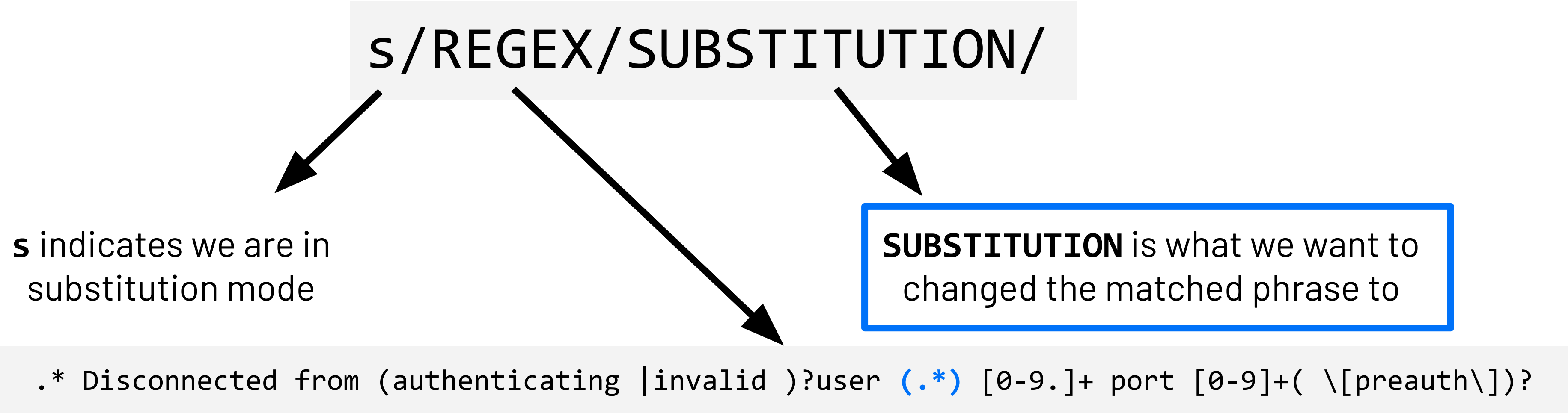

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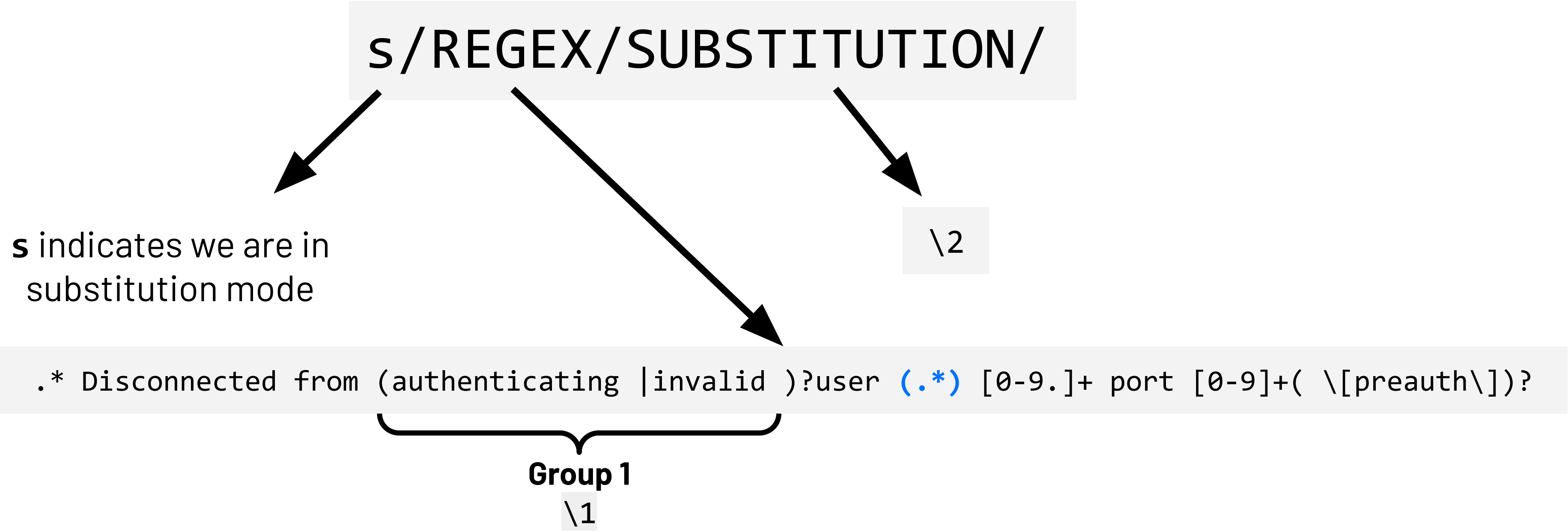


```
s/REGEX/SUBSTITUTION/
```

s indicates we are in substitution mode

```
\2
```

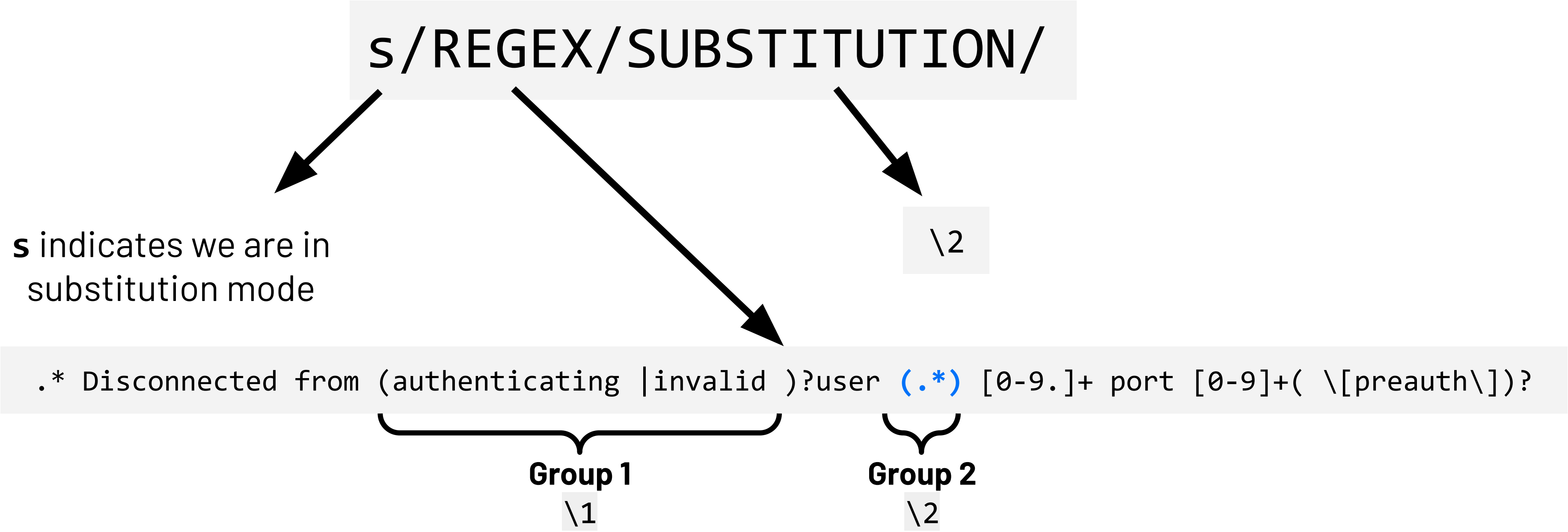
```
.* Disconnected from (authenticating |invalid )?user (.*) [0-9.]+ port [0-9]+( \[preauth\])?
```

Group 1

```
\1
```

Regular Expressions

Let's use `sed` for substitution.



```
s/REGEX/SUBSTITUTION/
```

s indicates we are in substitution mode

```
\2
```

```
.* Disconnected from (authenticating |invalid )?user (.*) [0-9.]+ port [0-9]+( \[preauth\])?
```

Group 1

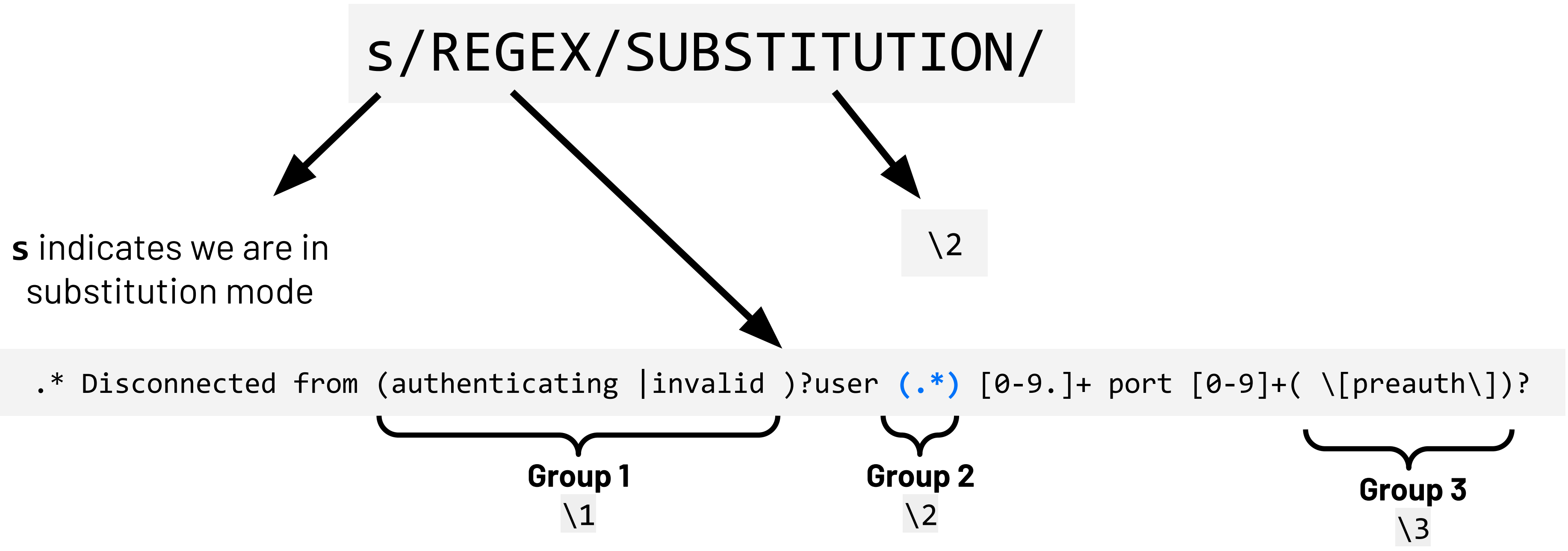
`\1`

Group 2

`\2`

Regular Expressions

Let's use `sed` for substitution.



```
s/REGEX/SUBSTITUTION/
```

s indicates we are in substitution mode

```
\2
```

```
.* Disconnected from (authenticating |invalid )?user (.*) [0-9.]+ port [0-9]+( \[preauth\])?
```

Regular Expressions

Let's use sed for substitution.

```
s/.* Disconnected from (authenticating |invalid )?user (.*) [0-9.]+ port [0-9]+( \[preauth\])?/\2/
```

Basic Data Wrangling: sed

Common Pitfalls and Usage Notes:

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- sed assumes data instances makes one substitution *per line*. If you want sed to keep repeating the substitution process for all instances on that line, use /g:

```
sed 's/AY21-22/AY22-23/g' file.txt
```

Basic Data Wrangling: sed

Common Pitfalls and Usage Notes:

- sed assumes data instances makes one substitution *per line*. If you want sed to keep repeating the substitution process for all instances on that line, use /g:

  ```
  sed 's/AY21-22/AY22-23/g' file.txt
  ```

- If you want to use a regex with sed, make sure to include the `-E` flag:

  ```
  sed -E 's/AY[0-9]{2}-[0-9]{2}/AY22-23' file.txt
  ```

Useful Commands

Now that we have all of the usernames, we can run some analysis on the data!

`sort` is a command that will arrange (i.e. sort) the data alphabetically or numerically.

The `-n` flag indicates to `sort` the data numerically.

Useful Commands

`uniq` is a command that reports or filters out the repeated lines in a file.

The `-c` flag is especially useful as it reports unique lines in the file and counts the number of occurrences for each line.

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`tail` is a command that prints the last lines X lines of a files

The `-n`*`X`* flag allows you to specify the number of lines you are interested in printing.

Useful Commands

`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

Let's look at an example!

Useful Commands

`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

```
adrazen@ayelet-computer ~ % cat filenames.txt
homework.txt
program.py
todo-list.txt
random.txt
```

Useful Commands

`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

```
touch homework.txt
```

```
touch program.py
```

```
touch todo-list.txt
```

```
touch random.txt
```

Useful Commands

`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

```
cat filenames.txt | xargs touch
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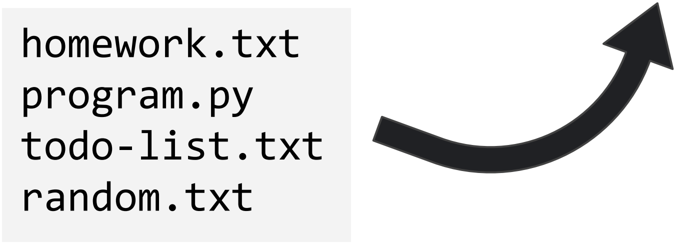

```
homework.txt
program.py
todo-list.txt
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Useful Commands

`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

```
cat filenames.txt | xargs touch homework.txt program.py
todo-list.txt random.txt
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cat filenames.txt | ~~xargs~~ touch homework.txt program.py todo-list.txt random.txt
```

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`xargs` is a command that allows you to use the output of one command as the *arguments* to another command.

```
cat filenames.txt | ~~xargs~~ touch homework.txt program.py
todo-list.txt random.txt
```

⚠

Other Commands and Tools

There are *many* useful commands, tools and languages out there for data wrangling. Here are a few to check out if you are interested:

`awk` is a scripting language for manipulating data and generating reports

`R` is another programming language that is great at data analysis and plotting.

`perl` is a programming language for text manipulation