# Software at Scale

CSSE6400

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Question

# How many concurrent users can your software handle?

Question

# How many concurrent users can your software handle?

Answer

Maybe *400*? Maximum.

Question

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Answer

# Maybe *400*[1]? Maximum.

[1] HTTP server on a t2.micro EC2 instance

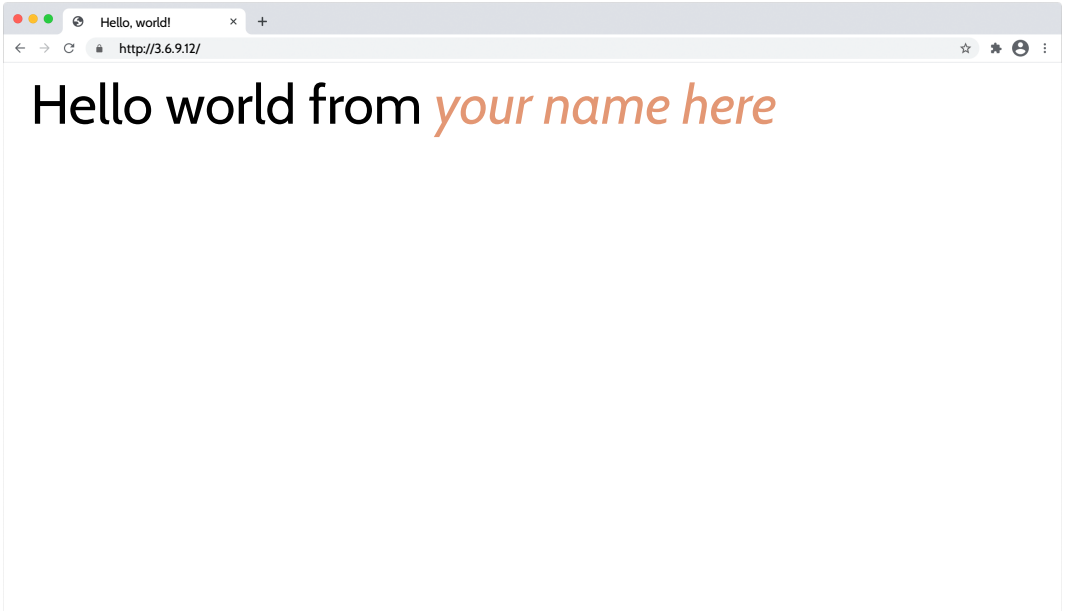
### Definition 1. Stress Testing

Measure the robustness of software by pushing usage to an extreme.

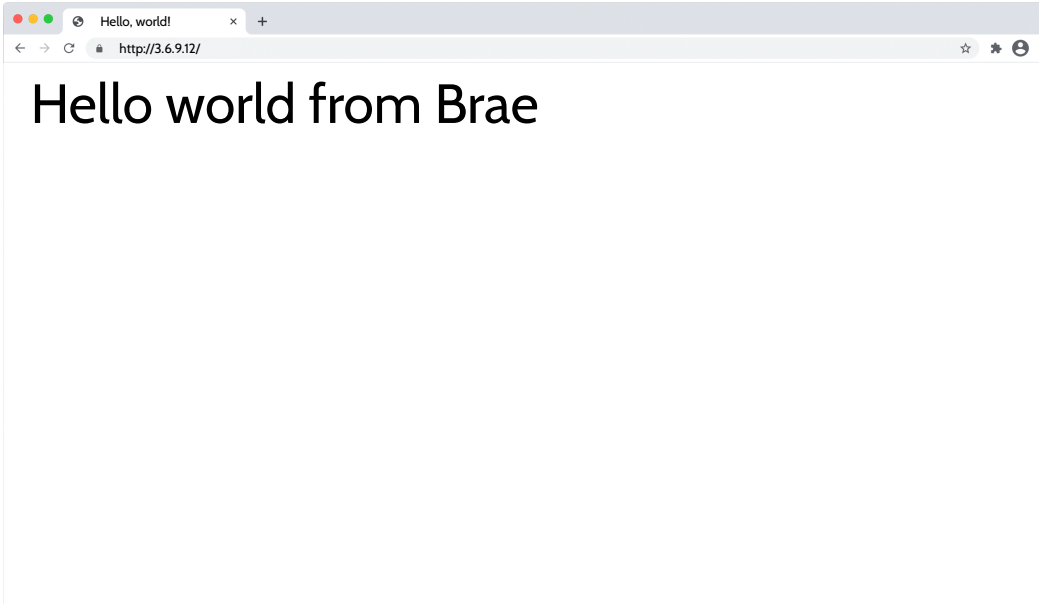
Demonstration

# Let’s build ‘hello world’

# Our Goal



# My Goal



```
» cat hello-server.tf
```

```
resource "aws_instance" "hello-server" {
    ami = "ami-04902260ca3d33422"
    instance_type = "t2.micro"
}
```

```
» cat hello-server.tf
```

```
resource "aws_instance" "hello-server" {
    ami = "ami-04902260ca3d33422"
    instance_type = "t2.micro"

    user_data = file("${path.module}/setup.sh")
}
```

```
» cat setup.sh
```

```
#!/bin/bash
yum -y install httpd
systemctl enable httpd
systemctl start httpd
echo '<html><title>Hello, world!</title><h1>Hello world from Brae</h1></html>' > /
    var/www/html/index.html
```

```
» cat hello-server.tf
```

```
resource "aws_instance" "hello-server" {
    ami = "ami-04902260ca3d33422"
    instance_type = "t2.micro"

    user_data = file("${path.module}/setup.sh")

    associate_public_ip_address = true
    subnet_id = module.network.subnets[0].public.id
    vpc_security_group_ids = [
        module.network.http-port.id
    ]
}
```

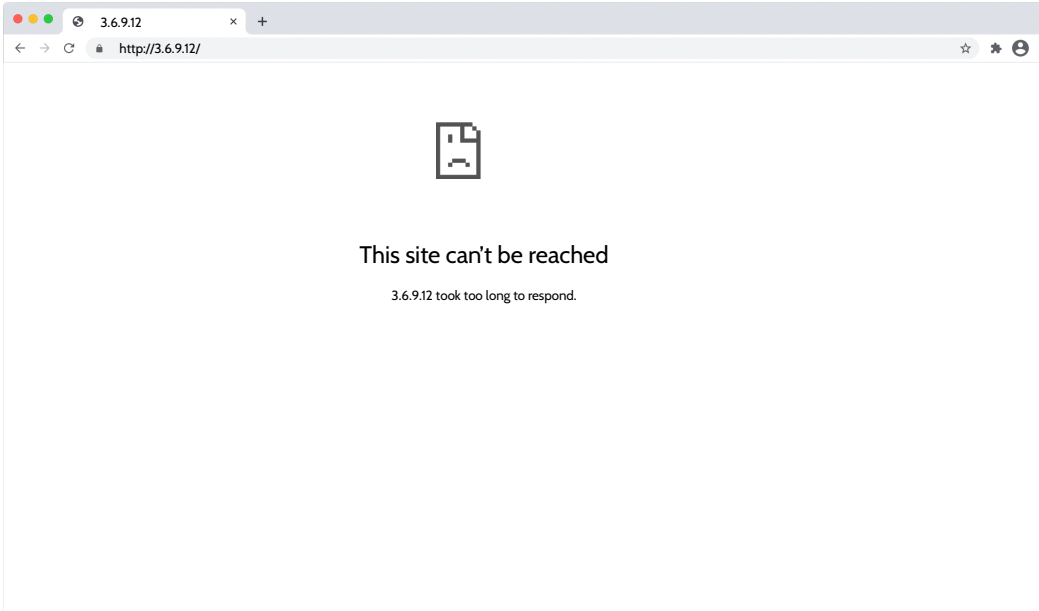
```
» cat hello-server.tf
```

```
resource "aws_instance" "hello-server" {
    ami = "ami-04902260ca3d33422"
    instance_type = "t2.micro"

    user_data = file("${path.module}/setup.sh")

    associate_public_ip_address = true
    subnet_id = module.network.subnets[0].public.id
    vpc_security_group_ids = [
        module.network.http-port.id
    ]

    tags = {
        Name = "hello-server"
    }
}
```

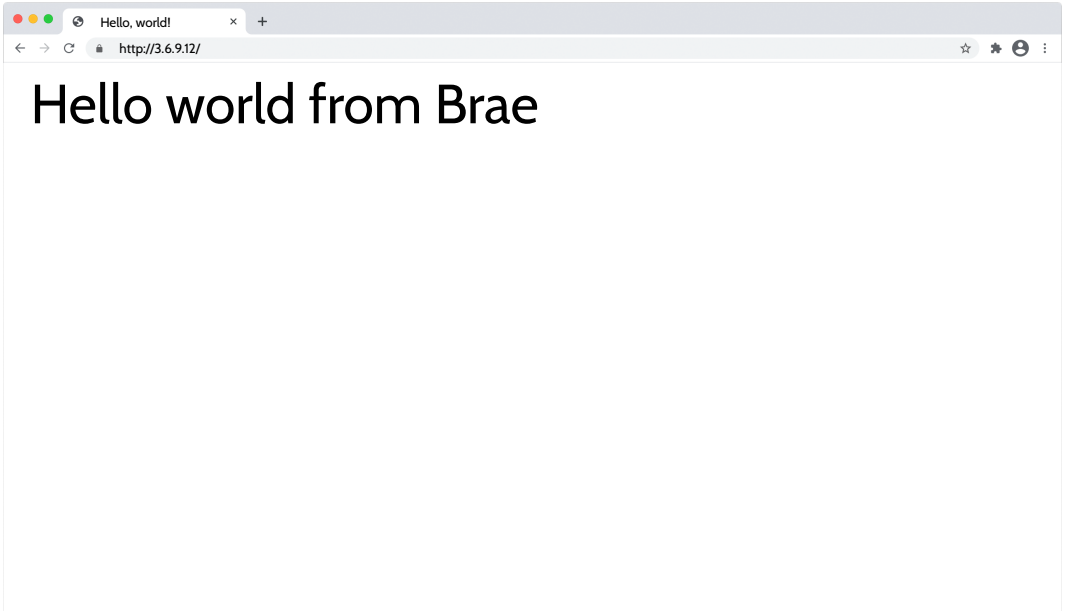
## Starting the server

```
>> terraform init
>> terraform plan
>> terraform apply
```

# Before


3.6.9.12
http://3.6.9.12/
This site can't be reached
3.6.9.12 took too long to respond.

## After



Question

# How much traffic can this website handle?

```
» cat stress-test.js
```

```
1  import http from 'k6/http';
2  import { check, sleep } from 'k6';
3
4  const IP = "http://3.6.9.12/";
5  export default function() {
6      const res = http.get(IP);
7      check(res, { 'status was 200': (r) => r.status == 200 });
8      sleep(1);
9  }
```

```
» cat stress-test.js
```

```
import http from 'k6/http';
import { check, sleep } from 'k6';

const IP = "http://3.6.9.12/";
export const options = {
    stages: [
        { duration: '2m', target: 100 },
    ],
};
export default function() {
    const res = http.get(IP);
    check(res, { 'status was 200': (r) => r.status == 200 });
    sleep(1);
}
```

## Run the tests

```
>> k6 run stress-test.js
```

## Looks good so far

```
 status was 200
  100% - 347867 / 0

checks.....................: 100%
data_received..............: 100 MB 44 kB/s
data_sent..................: 27 MB 12 kB/s
iterations.................: 347997 152.552084/s
vus........................: 1 min=1 max=400
```

## Let's upgrade the traffic

```
» cat stress-test.js
```

```
export const options = {
    stages: [
        { duration: '2m', target: 100 },
        { duration: '5m', target: 100 },
        { duration: '2m', target: 200 },
        { duration: '5m', target: 200 },
        { duration: '2m', target: 300 }, // around the breaking point
        { duration: '5m', target: 300 },
        { duration: '2m', target: 400 }, // beyond the breaking point
        { duration: '5m', target: 400 },
        { duration: '2m', target: 0 }, // scale down
    ],
};
```

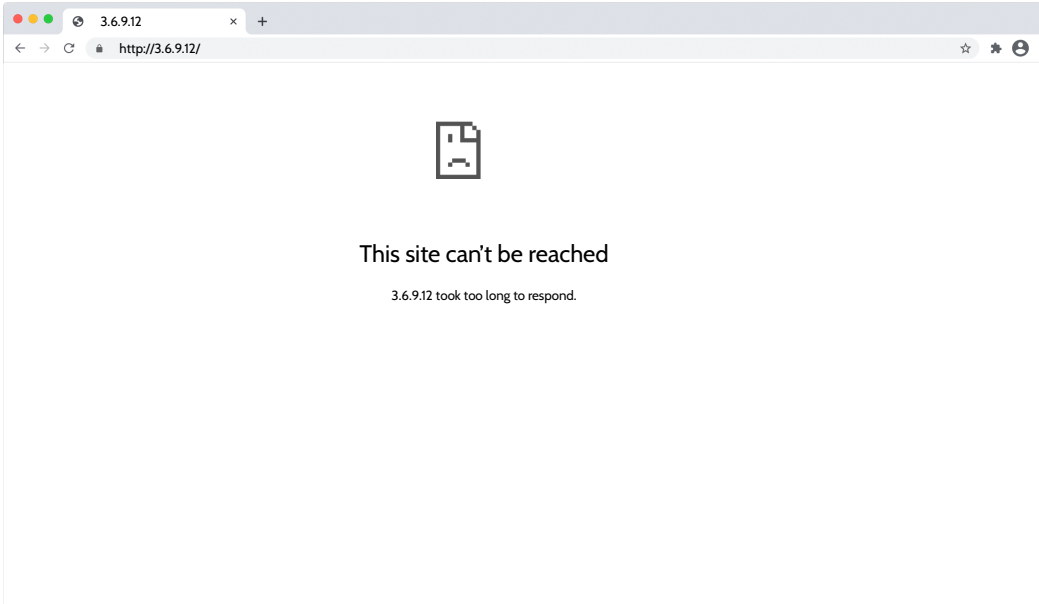
And run the tests again

```
>> k6 run stress-test.js
```

## Oh no...

```
status was 200
99% - 347867 / 130

checks.....................: 99.96%
data_received..............: 100 MB 44 kB/s
data_sent..................: 27 MB 12 kB/s
iterations.................: 347997 152.552084/s
vus........................: 1 min=1 max=400
```

# Back to square one



Question

# How can we fix this?

Question

# How can we fix this?

Answer

# More servers?

```
» cat hello-server.tf
```

```
resource "aws_instance" "hello-server" {
    ami = "ami-04902260ca3d33422"
    instance_type = "t2.micro"

    user_data = file("${path.module}/setup.sh")

    associate_public_ip_address = true
    subnet_id = module.network.subnets[0].public.id
    vpc_security_group_ids = [
        module.network.http-port.id
    ]

    tags = {
        Name = "hello-server"
    }
}
```

```
» cat hello-scale.tf
```

```
resource "aws_instance" "hello-server" {
  count = 4

  ami = "ami-04902260ca3d33422"
  instance_type = "t2.micro"
  user_data = file("${path.module}/setup.sh")

  associate_public_ip_address = true
  subnet_id = module.network.subnets[count.index].public.id
  vpc_security_group_ids = [
    module.network.http-port.id
  ]

  tags = {
    Name = "hello-server-${count.index}"
  }
}
```

### Definition 2. Target Group

A collection of EC2 instances.
More specifically, a collection of network connection points to EC2 instances.

## An empty HTTP target group

```
» cat hello-scale.tf
```

```
resource "aws_lb_target_group" "hello-target" {
  name = "hello-target-group"
  port = 80
  protocol = "HTTP"
  vpc_id = module.network.vpc.id
}
```

### Definition 3. Health Check

Monitors attributes of hardware or software to detect deficiencies.

## Add a health check

```
» cat hello-scale.tf
```

```
resource "aws_lb_target_group" "hello-target" {
  name = "hello-target-group"
  port = 80
  protocol = "HTTP"
  vpc_id = module.network.vpc.id

  health_check {
    port = 80
    protocol = "HTTP"
    timeout = 5
    interval = 10
  }
}
```

## Add our instances to the target group

```
» cat hello-scale.tf
```

```
resource "aws_lb_target_group_attachment" "hello-target-link" {
  count = length(aws_instance.hello-server)
  target_group_arn = aws_lb_target_group.hello-target.arn
  target_id = aws_instance.hello-server[count.index].id
  port = 80
}
```

Definition 4. Load Balancer

A networking tool to route and distribute traffic to targets.

## Create a load balancer

```
» cat hello-scale.tf
```

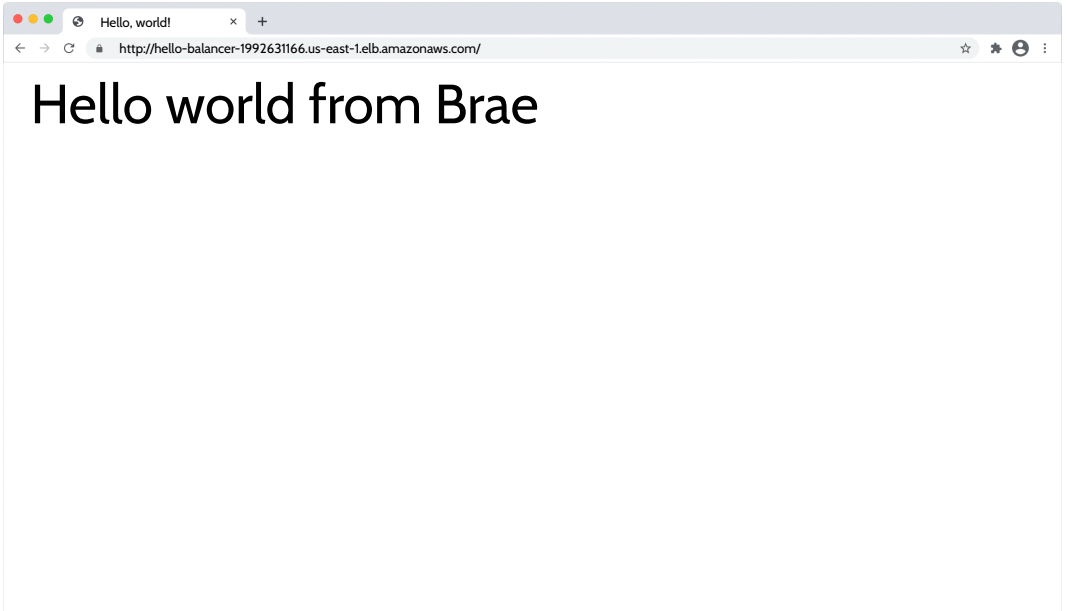
```
resource "aws_lb" "hello-balancer" {
  name = "hello-balancer"
  internal = false
  load_balancer_type = "application"
  subnets = [
    module.network.subnets[0].public.id,
    module.network.subnets[1].public.id,
    module.network.subnets[2].public.id,
    module.network.subnets[3].public.id
  ]
  security_groups = [
    module.network.http-port.id
  ]
}
```

## Route load balancer traffic to the target group

```
» cat hello-scale.tf
```

```
resource "aws_lb_listener" "app" {
  load_balancer_arn = aws_lb.hello-balancer.arn
  port = "80"
  protocol = "HTTP"

  default_action {
    type = "forward"
    target_group_arn = aws_lb_target_group.hello-target.arn
  }
}
```

# We're live!


Hello, world!
http://hello-balancer-1992631166.us-east-1.elb.amazonaws.com/
Hello world from Brae

Exercise

# Use *k6* to determine the new *load limits*

## References


[1] Martin Fowler.
Software architecture guide.
https://martinfowler.com/architecture/, August 2019.

[2] Matthias Galster and Samuil Angelov.
What makes teaching software architecture difficult?
In *Proceedings of the 38th International Conference on Software Engineering Companion*, ICSE '16, pages 356–359. Association for Computing Machinery, 2016.

[3] Robert C. Martin.
Design principles and design patterns.
https://web.archive.org/web/20150906155800/http://www.objectmentor.com/resources/articles/Principles_and_Patterns.pdf, 2000.
Accessed: 2022-01-10.

[4] Philippe Kruchten, Rafael Capilla, and Juan Carlos Duenas.
The decision view's role in software architecture practice.
*IEEE software*, 26(2):36–42, 2009.

[5] Michael Nygard.
Documenting architecture decisions.
`https://cognitect.com/blog/2011/11/15/documenting-architecture-decisions`, November 2011.
Accessed: 2022-01-27.

[6] Olaf Zimmermann.
Architectural decisions – the making of.
`https://ozimmer.ch/practices/2020/04/27/ArchitectureDecisionMaking.html`, March 2021.
Accessed: 2022-02-02.

[7] Eli Perkins.
Why write adrs.
https://github.blog/2020-08-13-why-write-adrs/, August 2020.
Accessed: 2022-02-02.

[8] Richard Thomas.
Architectural decision records.
February 2022.
https://csse6400.uqcloud.net/handouts/adr.pdf.

[9] Eric Boersma.
7 application security principles you need to know.
https://www.cprime.com/resources/blog/security-by-design-7-principles-you-need-to-know/, October 2020.

[10] Jerome H Saltzer and Michael D Schroeder.
The protection of information in computer systems.
*Proceedings of the IEEE*, 63(9):1278–1308, September 1975.

[11] Morrie Gasser.
*Building a Secure Computer System*, pages 35–44.
Van Nostrand Reinhold Company, January 1988.

[12] John Viega and Gary R McGraw.
*Building Secure Software: How to Avoid Security Problems the Right Way*, pages 91–113.
Addison-Wesley Professional, September 2001.

[13] Michael Howard and David LeBlanc.
*Security Principles To Live By*, page 64.
Microsoft Press Redmond, Wash., December 2002.

[14] Michael Gegick and Sean Barnum.
Failing securely.
`https://www.cisa.gov/uscert/bsi/articles/knowledge/principles/failing-securely`, December 2005.

[15] Santosh Janardhan.
More details about the October 4 outage.
https://engineering.fb.com/2021/10/05/networking-traffic/outage-details/, October 2021.

[16] C. E. Shannon.
Communication theory of secrecy systems.
*The Bell System Technical Journal*, 28(4):656–715, 1949.

[17] Sam Manjarres.
2021 world password day: How many will be stolen this year?
https://www.secplicity.org/2021/05/04/2021-world-password-day-how-many-will-be-stolen-this-year/, May 2021.

[18] Jerome H. Saltzer.
Protection and the control of information sharing in multics.
*Communications of the ACM*, 17(7):388–402, July 1974.

[19] Emma Roth.
Open source developer corrupts widely-used libraries, affecting tons of projects.
`https://www.theverge.com/2022/1/9/22874949/developer-corrupts-open-source-libraries-projects-affected`, January 2022.

[20] Brian Foote and Joseph Yoder.
Big ball of mud.
*Pattern languages of program design*, 4:654–692, 1997.

[21] Gulsah.
How to avoid spaghetti code.
`https://tech.zensurance.com/posts/spaghetti-code`, November 2020.
note = "Accessed: 2022-02-18".

[22] Jeffrey Dean and Sanjay Ghemawat.
Mapreduce: Simplified data processing on large clusters.
In *OSDI'04: Sixth Symposium on Operating System Design and Implementation*, pages 137–150, San Francisco, CA, 2004.

[23] David J. DeWitt and Michael Stonebraker.
Mapreduce: A major step backwards.
https://dsf.berkeley.edu/cs286/papers/backwards-vertica2008.pdf, January 2008.

[24] henszey.
Smallest x86 ELF hello world.
http://timelessname.com/elfbin/.

[25] Changhui Xu.
Docker: From scratch.
https://codeburst.io/docker-from-scratch-2a84552470c8, July 2020.

[26] Philippe Kruchten.
Architectural blueprints — the '4+1' view model of software architecture.
*IEEE software*, 12(6):42–50, 1995.
https://www.cs.ubc.ca/~gregor/teaching/papers/4+1view-architecture.pdf.

[27] Alexander Shvets.
Observer.
https://refactoring.guru/design-patterns/observer.
note = "Accessed: 2022-02-18".

[28] Tom Hilburn, Alice Squires, Heidi Davidz, and Richard Turner.
Federal aviation administration (faa) advanced automation system (aas).
https://www.sebokwiki.org/wiki/Federal_Aviation_Administration_(FAA)_Advanced_Automation_System_(AAS), October 2021.
Example from the *Guide to the Systems Engineering Body of Knowledge*
https://www.sebokwiki.org/w/index.php?title=Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK)&oldid=63222.

[29] AWS.
What is DevOps?
https://aws.amazon.com/devops/what-is-devops/.

[30] AWS.
DevOps and AWS: Tooling and infrastructure resources for DevOps practitioners.
`https://aws.amazon.com/devops/`.

[31] Matt Callanan and Alexandra Spillane.
DevOps: Making it easy to do the right thing.
*IEEE software*, 33(3):53–59, 2016.

[32] Mali Senapathi, Jim Buchan, and Hady Osman.
DevOps capabilities, practices, and challenges: Insights from a case study.
In *Proceedings of the 22nd International Conference on evaluation and assessment in software engineering 2018*, volume 137700 of *EASE'18*, pages 57–67. ACM, 2018.

[33] N.G. Leveson and C.S. Turner.
An investigation of the therac-25 accidents.
*Computer*, 26(7):18–41, 1993.

[34] John van Neumann.
Probabilistic logics and synthesis of reliable organisms from unreliable components, automata studies.
volume 34, pages 43–98, 1956.

[35] Ingrid Van Den Hoogen.
Deutsch's fallacies, 10 years after.
https://web.archive.org/web/20070811082651/http://java.sys-con.com/read/38665.htm, January 2004.

[36] Peter Jausovec.
Fallacies of distributed systems.
https://blogs.oracle.com/developers/post/fallacies-of-distributed-systems, November 2020.

[37] Raymond Lister, Colin Fidge, and Donna Teague.
Further evidence of a relationship between explaining, tracing and writing skills in introductory programming.
In *Proceedings of the 14th Annual ACM SIGCSE Conference on Innovation and Technology in Computer Science Education*, ITiCSE '09, page 161–165, New York, NY, USA, 2009. Association for Computing Machinery.

[38] Raymond Lister.
Concrete and other neo-piagetian forms of reasoning in the novice programmer.
In *Proceedings of the Thirteenth Australasian Computing Education Conference - Volume 114*, ACE '11, page 9–18, AUS, 2011. Australian Computer Society, Inc.

[39] Len Bass, Paul Clements, and Rick Kazman.
*Software Architecture in Practice.*
Addison-Wesley Professional, 3rd edition, September 2012.

[40] Len Bass, Paul Clements, and Rick Kazman.
*Software Architecture in Practice.*
Addison-Wesley, 4th edition, August 2021.

[41] David Garlan, Felix Bachmann, James Ivers, Judith Stafford, Len Bass, Paul Clements, and Paulo Merson.
*Documenting Software Architectures: Views and Beyond.*
Addison-Wesley Professional, 2nd edition, 2010.

[42] Mark Richards and Neal Ford.
*Fundamentals of Software Architecture: An Engineering Approach.*
O'Reilly Media, Inc., January 2020.

[43] Sam Newman.
*Building Microservices.*
O'Reilly Media, Inc., February 2015.

[44] Simon Brown.
*Software Architecture for Developers - Volume 2.*
Leanpub, January 2022.
https://leanpub.com/visualising-software-architecture.

[45] Philippe Kruchten.
*The Rational Unified Process: An Introduction.*
Addison-Wesley Professional, 2004.

[46] Gerald M. Weinberg.
*The Psychology of Computer Programming.*
John Wiley & Sons, Inc., USA, 1985.

[47] Andrew Hoffman.
*Web Application Security: Exploration and Countermeasures for Modern Web Applications.*
O'Reilly Media, Inc., 2020.

[48] Leszek A. Maciaszek.
*Requirements Analysis and System Design.*
Addison-Wesley Harlow, 3rd edition, 2007.

[49] Architecture Capability Team.
*NATO Architecture Framework.*
NATO, 4th edition, September 2020.

[50] Nick Rozanski and Eóin Woods.
*Software Systems Architecture: Working With Stakeholders Using Viewpoints and Perspectives.*
Addison-Wesley, 2nd edition, 2012.

[51] The Open Group Architecture Forum.
*The Open Group Architecture Framework Standard.*
The Open Group, 9.2 edition, 2018.
https://pubs.opengroup.org/architecture/togaf9-doc/arch/index.html.

[52] *ISO/IEC/IEEE 42010:2011*.
ISO, 2011.

[53] *Unified Modeling Language*.
OMG, 2.5.1 edition, December 2017.
`https://www.uml.org/`.

[54] Gernot Starke, Ulrich Becker, Carola Lilienthal, Michael Mahlberg, Simon Kölsch, Alexander Lorz, Andreas Rausch, Roger Rhoades, Sebastian Fichtner, Phillip Ghadir, Mahbouba Gharbi, Matthias Bohlen, Mirko Hillert, Peter Hruschka, and Wolfgang Fahl.
*iSAQB Glossary of Software Architecture Terminology*.
International Software Architecture Qualification Board, November 2020.
`https://leanpub.com/isaqbglossary/read`.

[55] Eric Evans.
*Domain-Driven Design: Tackling Complexity in the Heart of Software*.
Addison-Wesley Professional, August 2003.

[56] Martin Kleppmann.
*Designing Data-Intensive Applications: The big ideas behind reliable, scalable, and maintainable systems.*
O'Reilly Media, Inc., March 2017.