

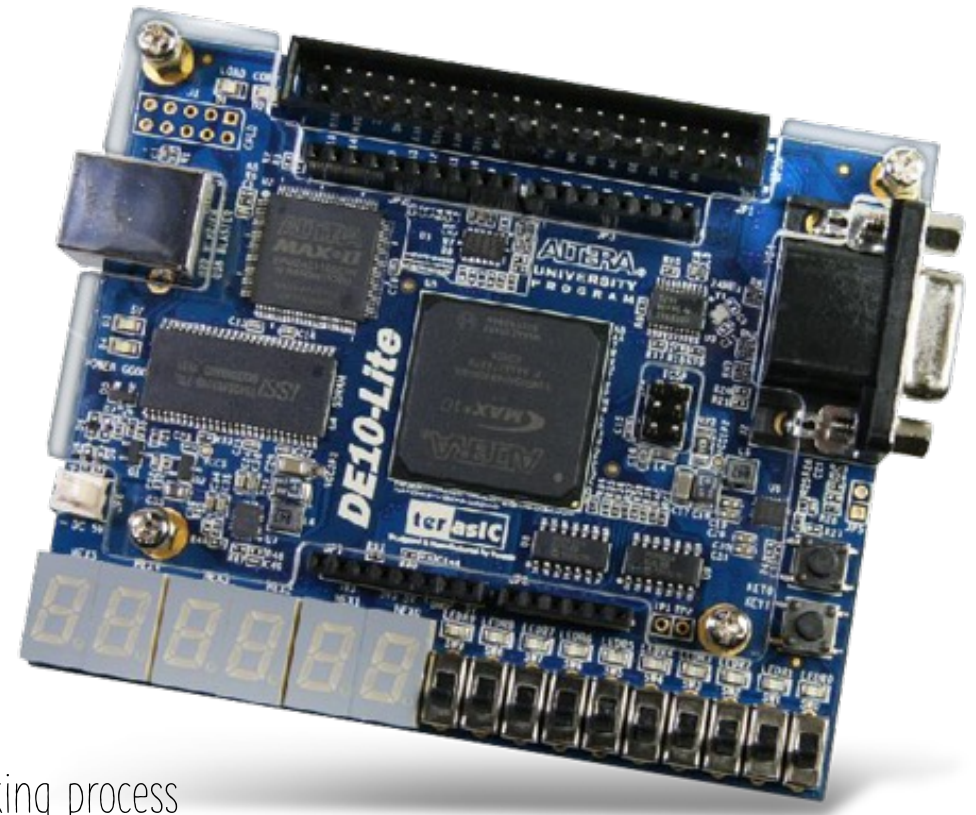
The background features a dark, textured surface with numerous out-of-focus, warm-toned bokeh lights scattered across the upper half. A large, vibrant green, rounded shape occupies the lower right portion of the frame, serving as a container for the title and author information.

Digital Circuit Design

Li Bai

What we will cover...

- Digital (we will need to learn everything about the binary ...)
- We will need to design a process based on input/state to move into different output
- Difference between Arduino and DE10-Lite
 - Advantage of FPGA -> check out [here](#)
- Quartus and EDA Playground
 - Quartus will be on AWS Academy
 - <https://edaplayground.com/>
- Learn combinatory logic, sequential logic, flip-flop, block diagram, timing diagram, making process



AWS Academy Student login


aws academy student login

1

×


All Perspectives Images Videos News More ▾ Tools

About 15,400,000 results (0.19 seconds)

 AWS Academy Portal
<https://www.awsacademy.com>

AWS Academy Portal


We have launched a new **login** experience for all **AWS Academy** users. Please re ... Forgot your Password? Are you a **student**? information. close image. If you are ...

 Instructure
<https://awsacademy.instructure.com> · [Translate this page](#)

Untitled

2

学生の方はここからログインしてください。已注册课程的学生请在这里登录. Educator Login. (For educators who have access to the **AWS Academy Portal**).

 Instructure
<https://awsacademy.instructure.com> › login › canvas

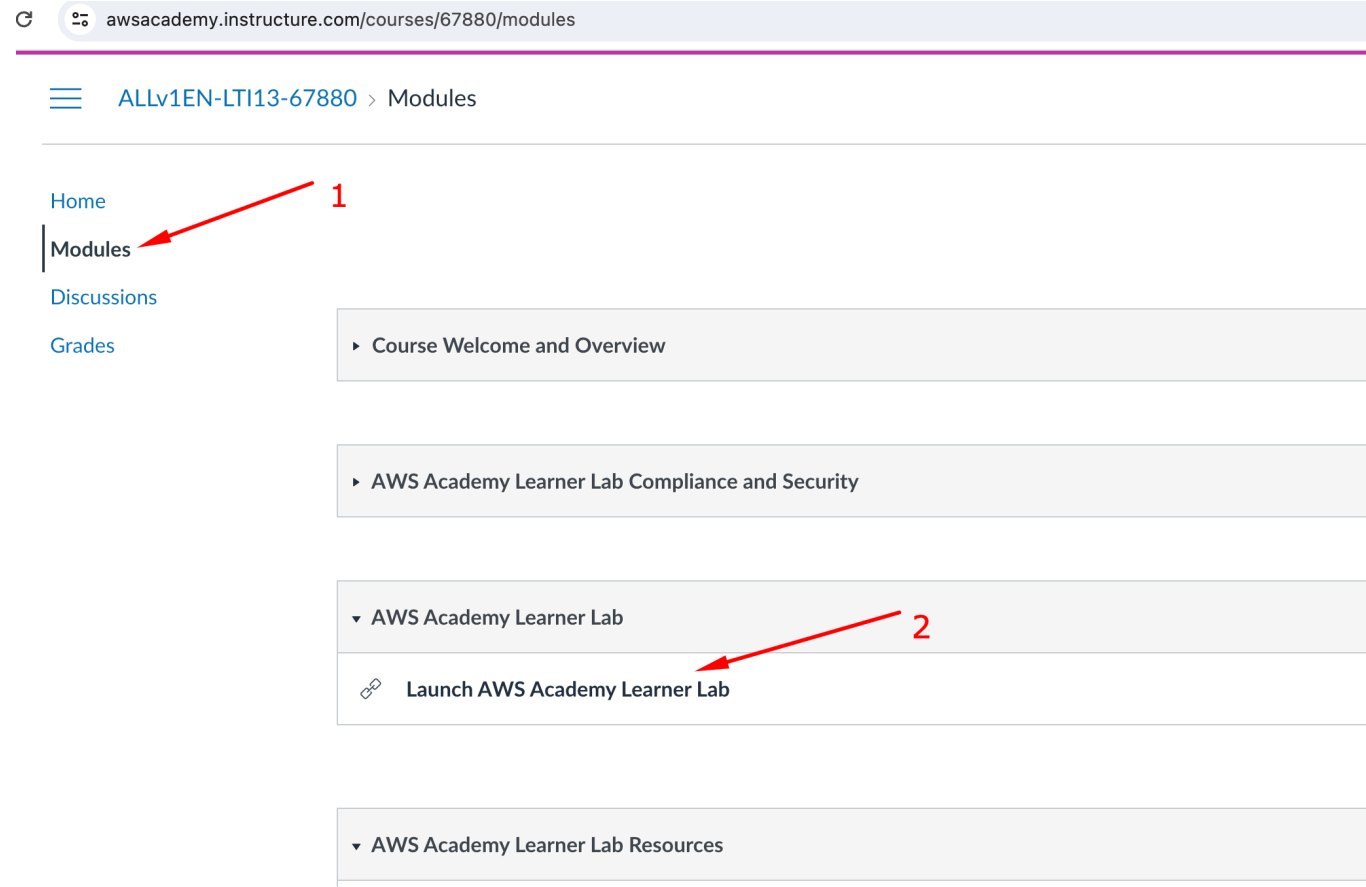
Canvas - Amazon AWS Academy Login - Instructure

Canvas by Instructure. **Log In**. Forgot Password? Enter your Email and we'll send you a link to

AWS Academy Canvas

The screenshot shows the AWS Academy Canvas dashboard at `awsacademy.instructure.com`. The interface includes a top navigation bar with the AWS Academy logo and a user profile icon labeled "Account". A left sidebar contains navigation links: "Dashboard" (highlighted with a red arrow and labeled "1"), "Courses", "Calendar", "Inbox" (with a notification badge of 11), "History", and "Help" (with a notification badge of 10). The main content area is titled "Published Courses (20)" and displays a grid of course cards. A red arrow labeled "2" points to the three-dot menu icon on the top right of the first course card. A modal window is open over the first card, titled "Color Move X", with a "Nickname" field containing "ECE2613-spring 2023" (highlighted with a red arrow and labeled "3"). Below the nickname field is a color palette with 24 color swatches and a text input showing the hex code "#986C16". The modal also includes "Cancel" and "Apply" buttons. The course cards visible include "ECE2613-spring 2023" (brown), "Robotic Control 2023" (pink), "IEEE - Minipupper" (magenta), and others.

Access Learner's Lab



The screenshot shows the AWS Academy Learner's Lab interface. At the top, the browser address bar displays the URL `awsacademy.instructure.com/courses/67880/modules`. Below the address bar, the breadcrumb navigation shows `ALLv1EN-LTI13-67880 > Modules`. On the left side, there is a vertical navigation menu with the following items: `Home`, `Modules`, `Discussions`, and `Grades`. A red arrow labeled `1` points to the `Modules` item in this menu. The main content area on the right displays a list of course modules. The first module is `Course Welcome and Overview`. The second module is `AWS Academy Learner Lab Compliance and Security`. The third module is `AWS Academy Learner Lab`, which is expanded to show a sub-item `Launch AWS Academy Learner Lab`. A red arrow labeled `2` points to this sub-item. The fourth module is `AWS Academy Learner Lab Resources`.

awsacademy.instructure.com/courses/67880/modules

ALLv1EN-LTI13-67880 > Modules

Home
Modules
Discussions
Grades

▸ Course Welcome and Overview

▸ AWS Academy Learner Lab Compliance and Security

▼ AWS Academy Learner Lab

🔗 Launch AWS Academy Learner Lab

▼ AWS Academy Learner Lab Resources

Accept terms and conditions

-LTI... > Modules > AWS Acade... > Launch AWS Academy Learner Lab

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Home Classes

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Start lab

awsacademy.instructure.com/courses/67880/modules/items/6035341



ALLv1EN-LTI... > Modules > AWS Acade... > Launch AWS Academy Learner Lab

AWS ●

▶ Start Lab

■ End Lab

i AWS Details

i Readme

↺ Reset



ne

ules

ussions

des

```
eee_W_2764216@runweb109510:~$
```

EN-US

Learner Lab

[Environment Overview](#)

[Environment Navigation](#)


[Access the AWS Management Console](#)

[Region restriction](#)

[Service usage and other restrictions](#)

AWS green -> go to console

... > Modules > AWS Acade... > Launch AWS Academy Learner Lab

AWS  Used \$0 of \$100 03:58 ▶ Start Lab ■ End Lab ⓘ AWS Details ⓘ Reac

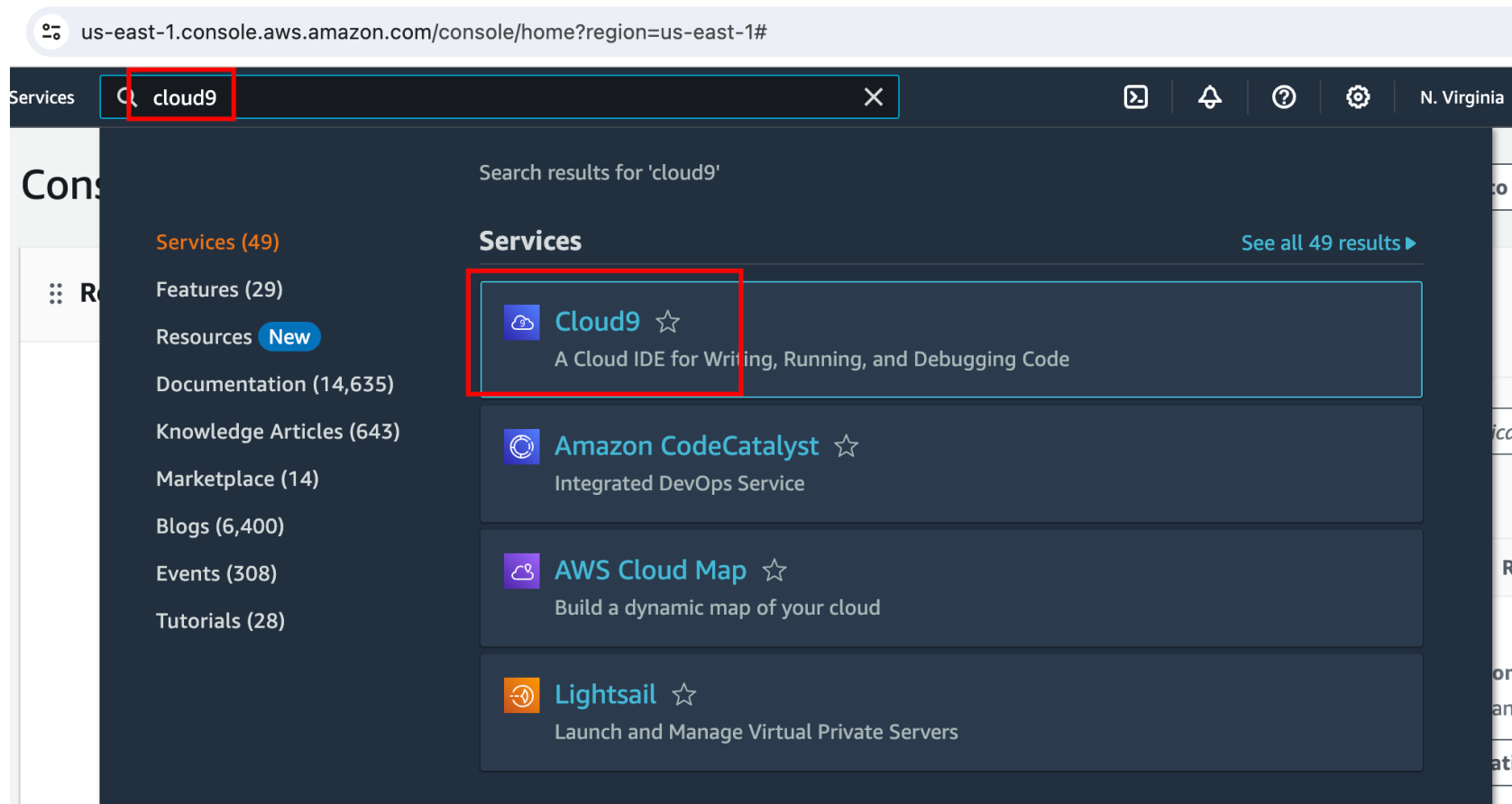
eee_w_2764216@runweb109509:~\$

EN-US

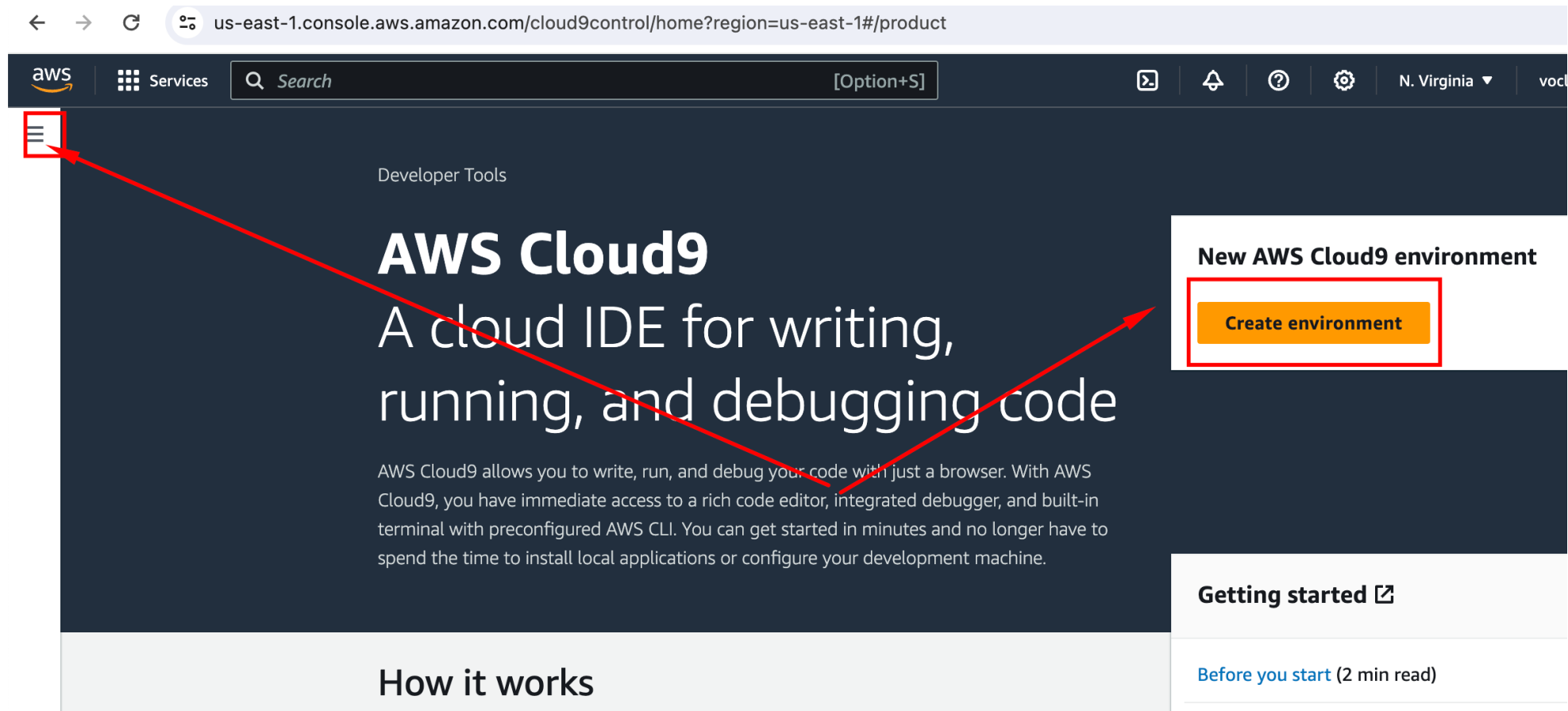
Learner La

- [Environment Overview](#)
- [Environment Navigation](#)
- [Access the AWS Managen](#)
- [Region restriction](#)
- [Service usage and other r](#)
- [Using the terminal in the](#)
- [Running AWS CLI comma](#)
- [Using the AWS SDK for Py](#)
- [Preserving your budget](#)
- [Accessing EC2 Instances](#)
- [SSH Access to FC2 Instan](#)

Find cloud9



Create environment



The screenshot shows the AWS Cloud9 console interface. At the top, the browser address bar displays the URL: `us-east-1.console.aws.amazon.com/cloud9control/home?region=us-east-1#/product`. The AWS navigation bar includes the AWS logo, a 'Services' menu, a search bar, and a '[Option+S]' shortcut. On the right side of the navigation bar, there are icons for notifications, help, settings, and the current region 'N. Virginia'. The main content area has a dark blue background with the heading 'Developer Tools' and 'AWS Cloud9'. Below this, it says 'A cloud IDE for writing, running, and debugging code'. A red arrow points from the left sidebar menu (indicated by a red box around the menu icon) to the 'Create environment' button in the 'New AWS Cloud9 environment' section. The button is orange and labeled 'Create environment'. Below this section, there is a 'Getting started' link with an external icon, and a link to 'Before you start (2 min read)'.

us-east-1.console.aws.amazon.com/cloud9control/home?region=us-east-1#/product

aws Services Search [Option+S]

N. Virginia ▼

Developer Tools

AWS Cloud9

A cloud IDE for writing, running, and debugging code

AWS Cloud9 allows you to write, run, and debug your code with just a browser. With AWS Cloud9, you have immediate access to a rich code editor, integrated debugger, and built-in terminal with preconfigured AWS CLI. You can get started in minutes and no longer have to spend the time to install local applications or configure your development machine.

New AWS Cloud9 environment

Create environment

Getting started

[Before you start](#) (2 min read)

How it works

Services

Q Search

[Option+S]

New EC2 instance

Instance type [Info](#)

The memory and CPU of the EC2 instance that will be created for Cloud9 to run on.

☐ t2.micro (1 GiB RAM + 1 vCPU)
Free-tier eligible. Ideal for educational users and exploration.

☐ t3.small (2 GiB RAM + 2 vCPU)
Recommended for small web projects.

☐ m5.large (8 GiB RAM + 2 vCPU)
Recommended for production and most general-purpose development.

☒ Additional instance types
Explore additional instances to fit your need.

Additional instance types

c4.xlarge ▼

Platform [Info](#)

This will be installed on your EC2 instance. We recommend Amazon Linux 2023.

Ubuntu Server 22.04 LTS ▼

Timeout

How long Cloud9 can be inactive (no user input) before auto-hibernating. This helps prevent unnecessary charges.

30 minutes ▼

Network settings [Info](#)

Finalize your cloud9 environment

Network settings [Info](#)


Connection
How your environment is accessed.


☐ **AWS Systems Manager (SSM)**
Accesses environment via SSM without opening inbound ports (no ingress).

☒ **Secure Shell (SSH)**
Accesses environment directly via SSH, opens inbound ports.

► **VPC settings** [Info](#)

► **Tags - optional** [Info](#)
A tag is a label that you assign to an AWS resource. Each tag consists of a key and an optional value. You can use tags to search and filter your resources or track your AWS costs.

 **The following IAM resources will be created in your account**

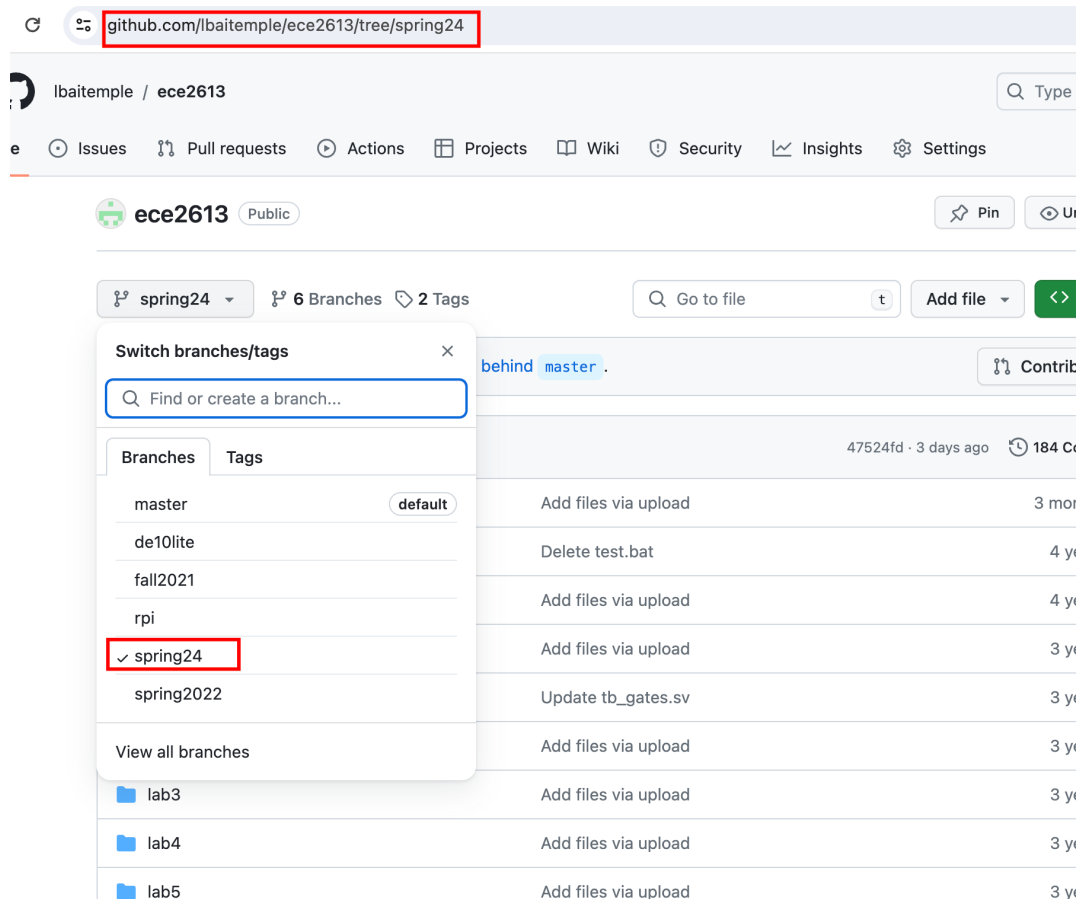
- **AWSServiceRoleForAWSCloud9** - AWS Cloud9 creates a service-linked role for you. This allows AWS Cloud9 to call other AWS services on your behalf. You can delete the role from the AWS IAM console once you no longer have any AWS Cloud9 environments. [Learn more](#) 

Cancel

Create

- c4.xlarge
- Ubuntu22.04
- ssh

Instruction on github



The screenshot shows the GitHub repository page for `lbaitemple/ece2613`. The URL bar highlights `github.com/lbaitemple/ece2613/tree/spring24`. The repository is public and has 6 branches and 2 tags. The 'Switch branches/tags' dropdown menu is open, showing a list of branches: `master` (default), `de10lite`, `fall2021`, `rpi`, `✓ spring24` (selected), and `spring2022`. Below the branches list, there are folders labeled `lab3`, `lab4`, and `lab5`. The main content area shows a list of files and folders, including `Add files via upload`, `Delete test.bat`, `Add files via upload`, `Add files via upload`, `Update tb_gates.sv`, `Add files via upload`, `Add files via upload`, and `Add files via upload`.

2613_2024s

Instruction is provided at <https://sites.google.com/a/template.edu/ece2612/home/cloud9-setup>

after you select the instance for cloud9, in the terminal

```
git clone -b spring24 https://github.com/lbaitemple/ece2613
cd ece2613
bash ./setup.bash
sudo reboot
```



Test the code

- right click on `m_sim` (extension file) and run
- right click on `qs_f` (extension file) and run

Resize cloud9 terminal windows

AWS Cloud9

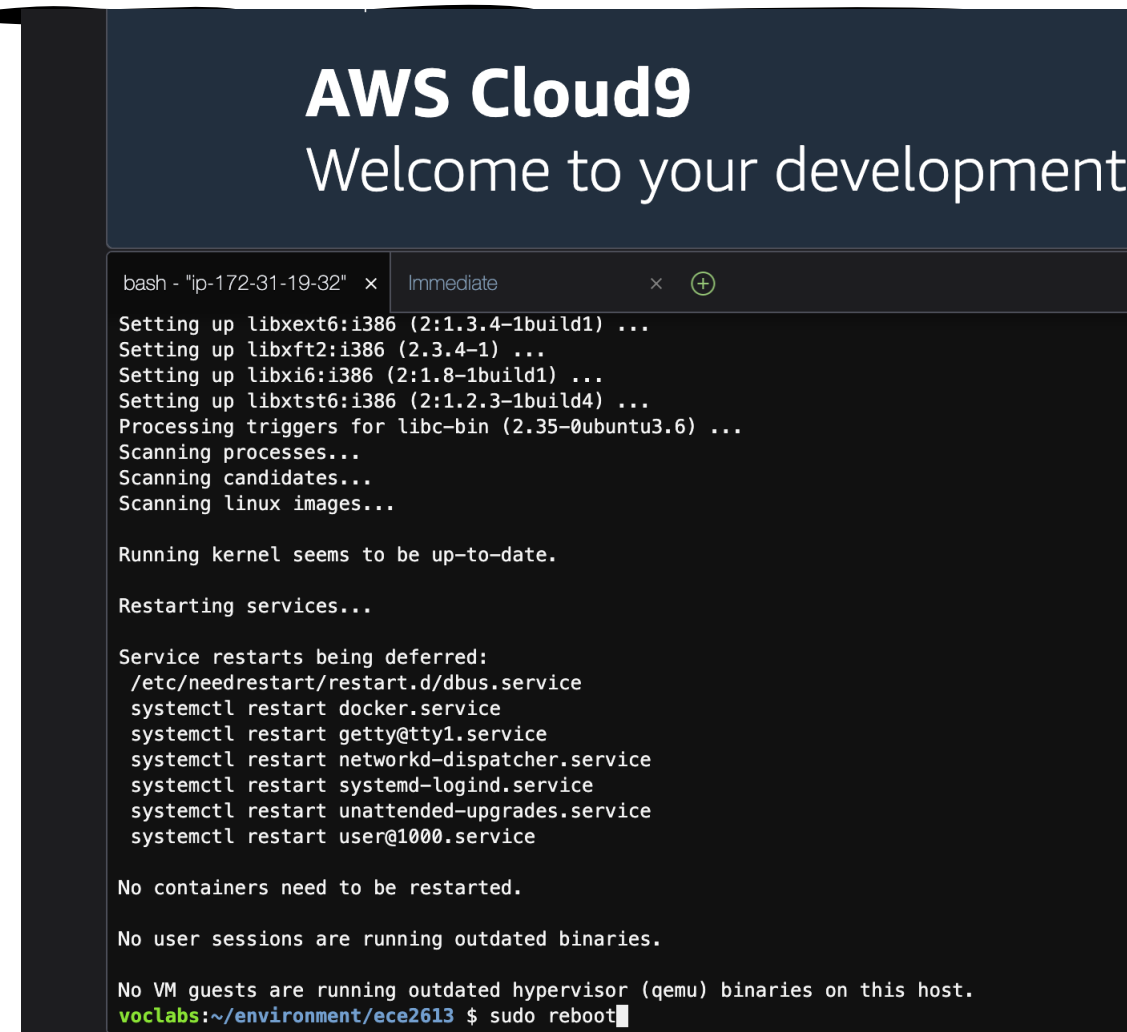
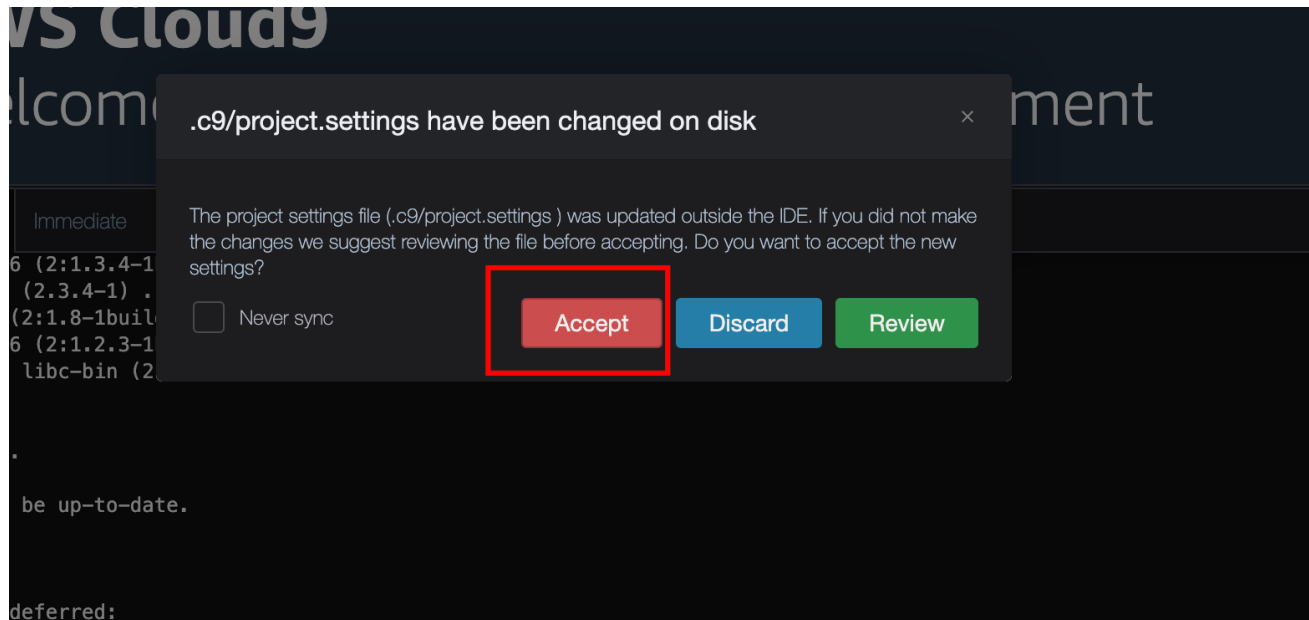
Welcome to your development environment

```
bash - "jp-172-31-19-32" x Immediate x +
Get:17 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:18 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1277 kB]
Get:19 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [261 kB]
Get:20 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/main amd64 c-n-f Metadata [16.1 kB]
Get:21 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1272 kB]
Get:22 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [207 kB]
Get:23 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 c-n-f Metadata [520 B]
Get:24 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1023 kB]
Get:25 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [228 kB]
Get:26 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:27 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:28 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:29 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:30 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:31 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:32 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:33 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:34 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:35 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:36 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:37 http://us-east-1.ec2.archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Get:38 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1062 kB]
Get:39 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [201 kB]
Get:40 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1244 kB]
Get:41 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [203 kB]
Get:42 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [826 kB]
Get:43 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [156 kB]
93% [14 Commands-amd64 store 0 B]
```

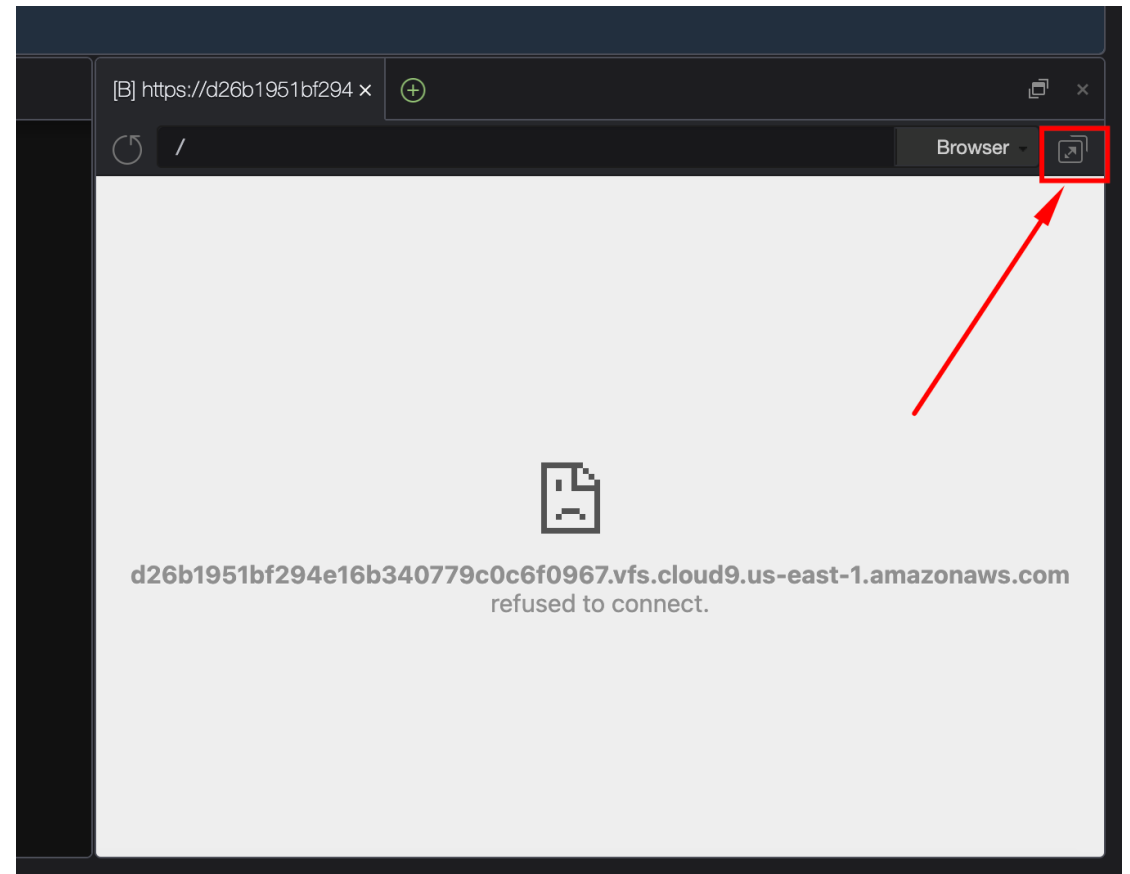
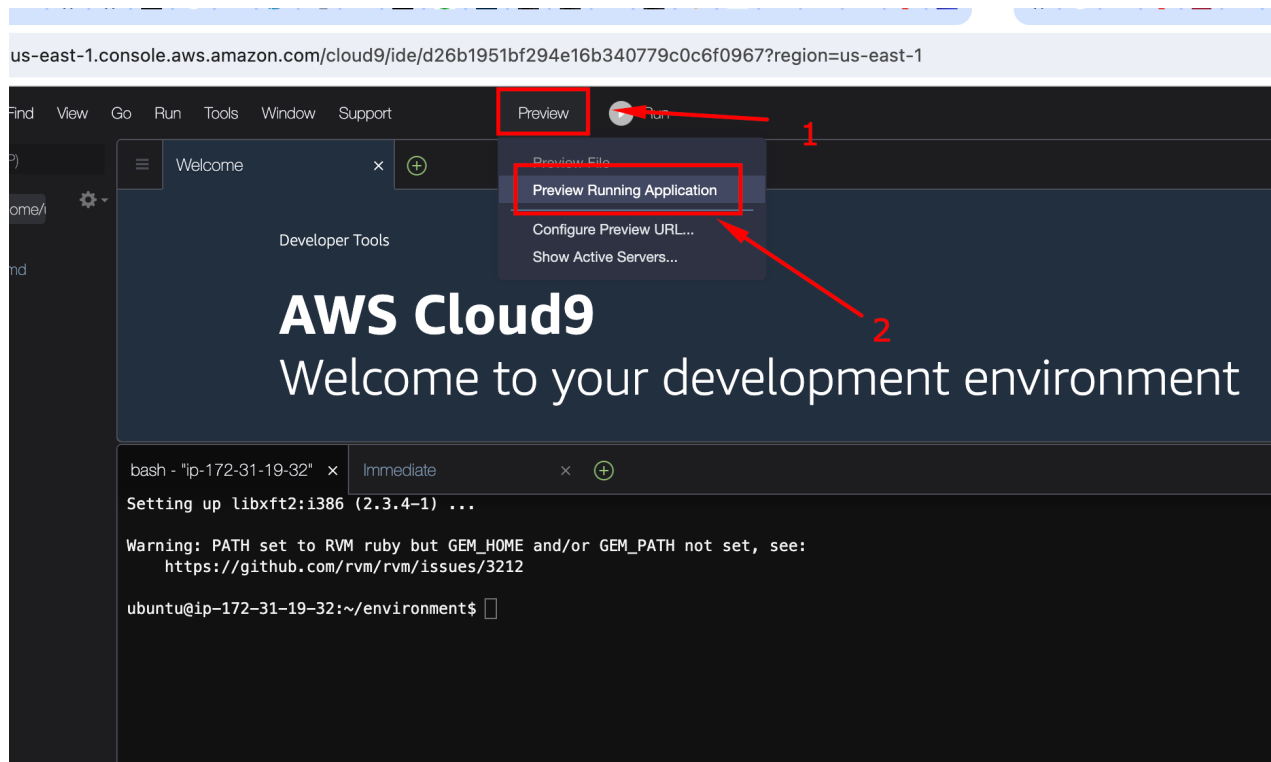
After about 15-20 minutes...

sudo reboot

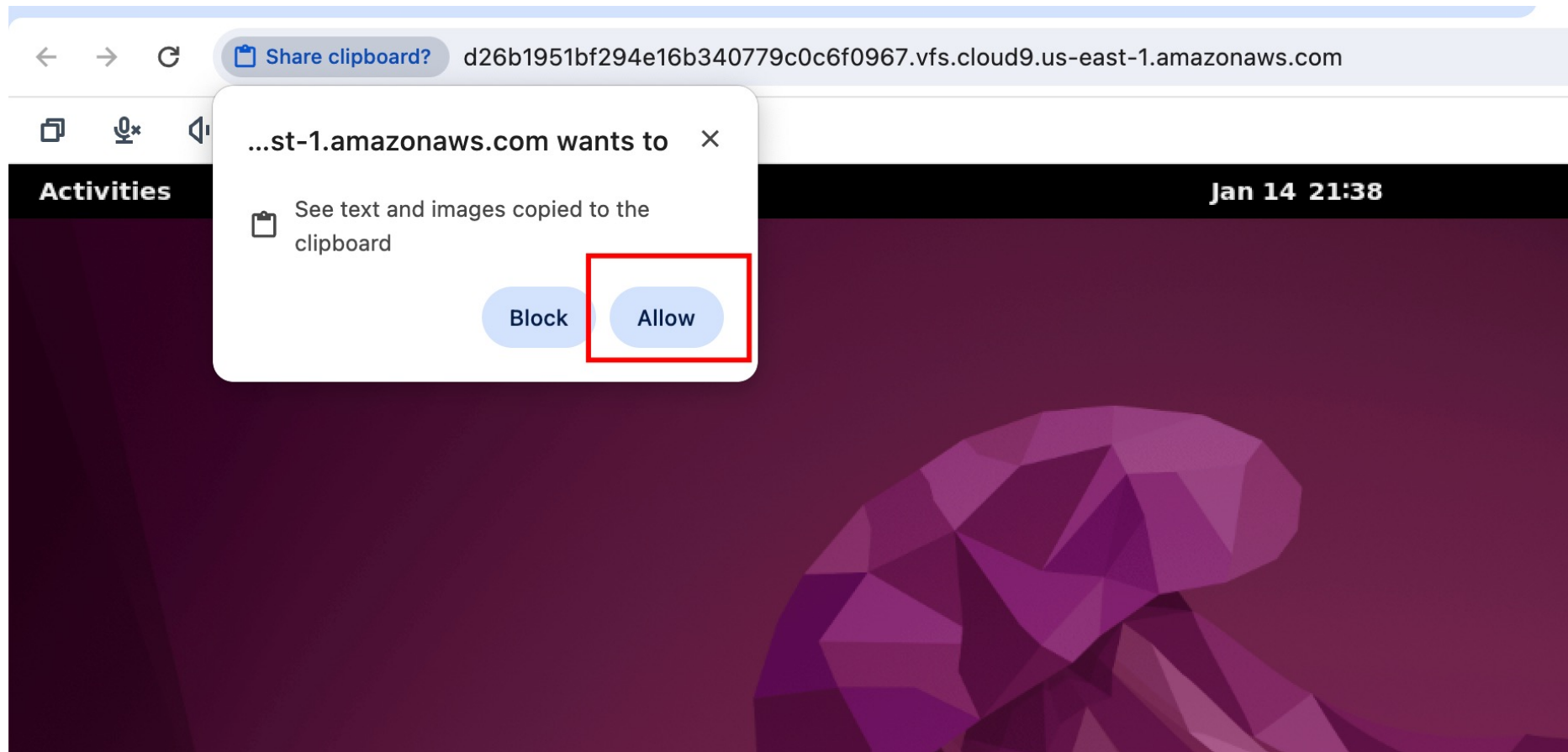
Reboot the system



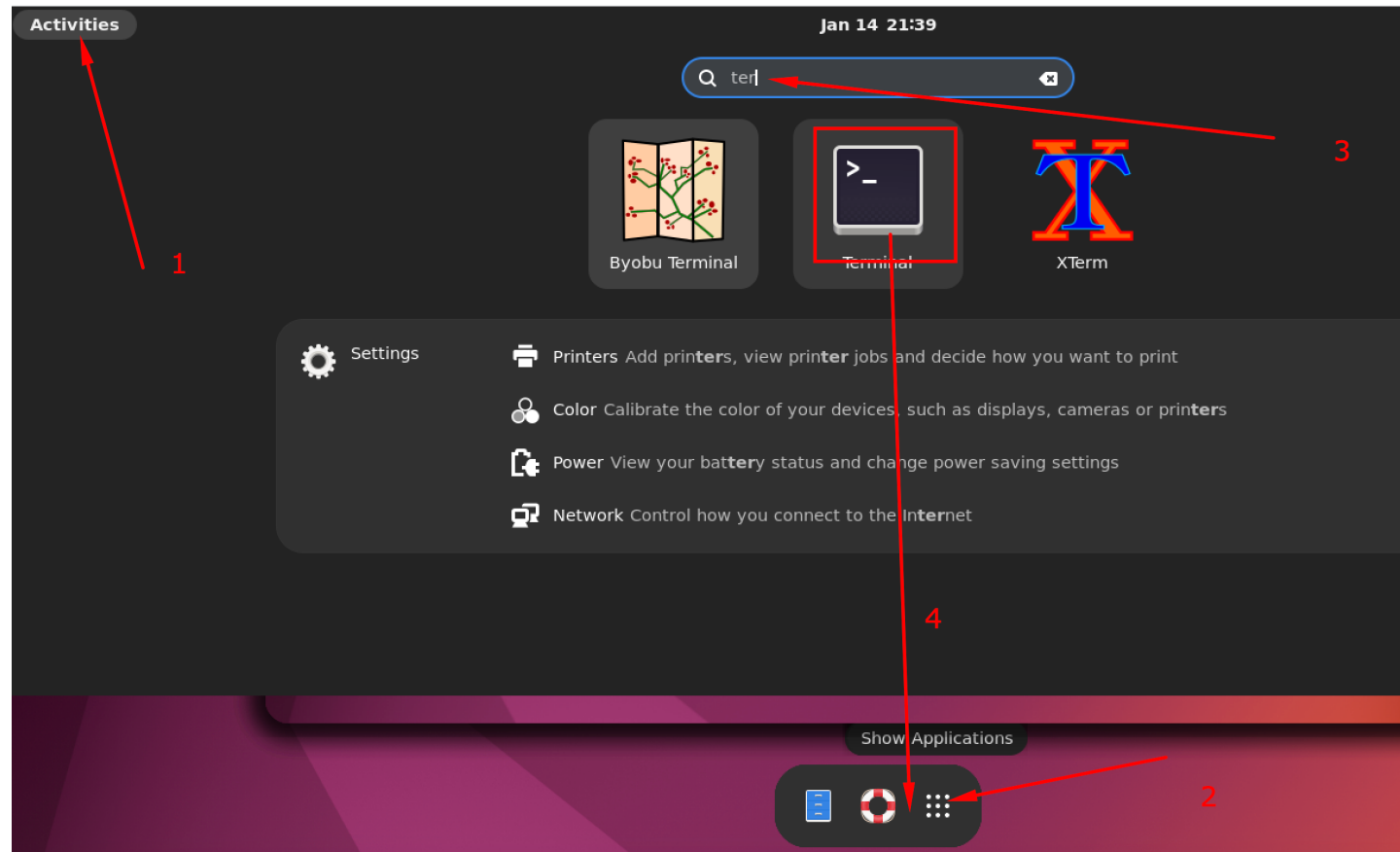
Xwindow access



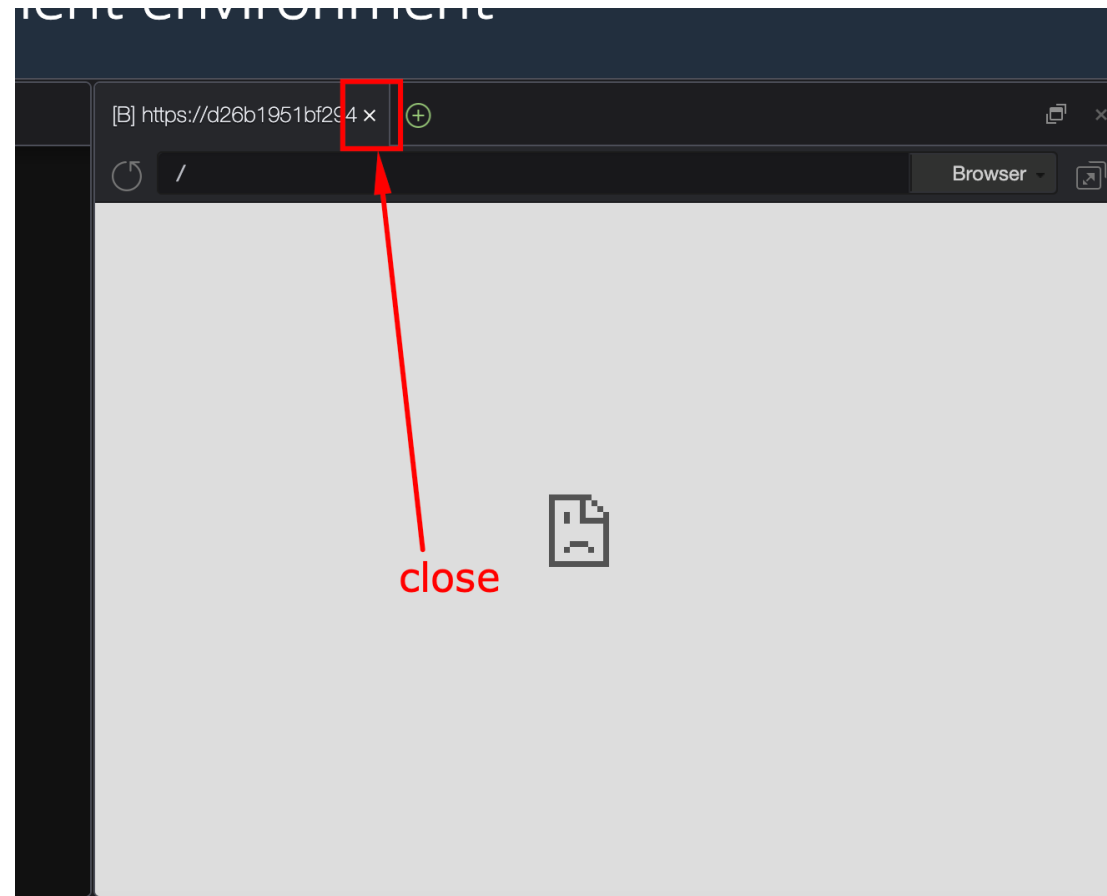
Allow xwindow



Place terminal in task bar

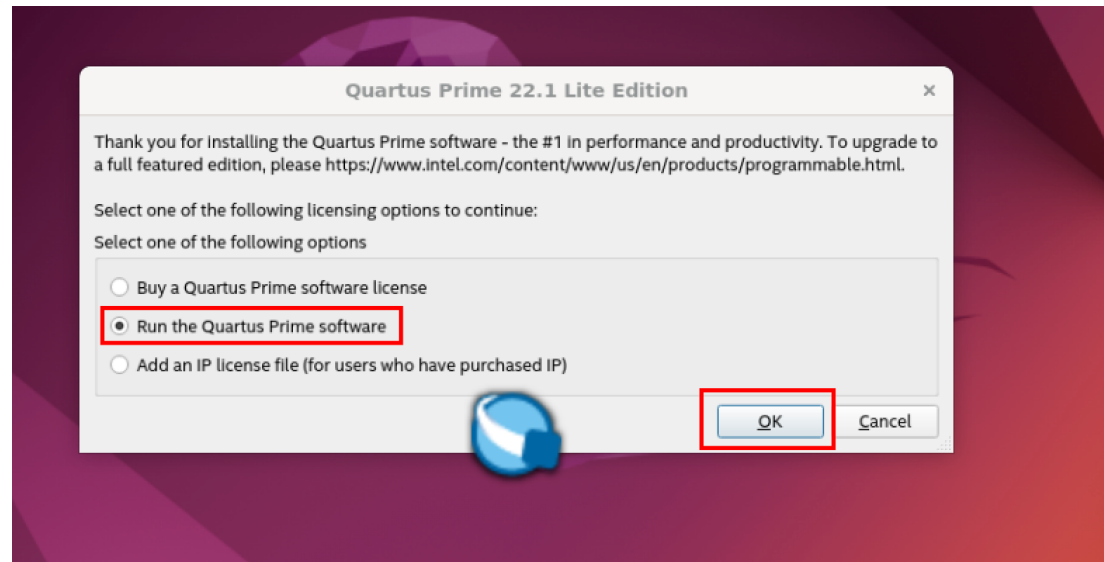


Close access to xwindow

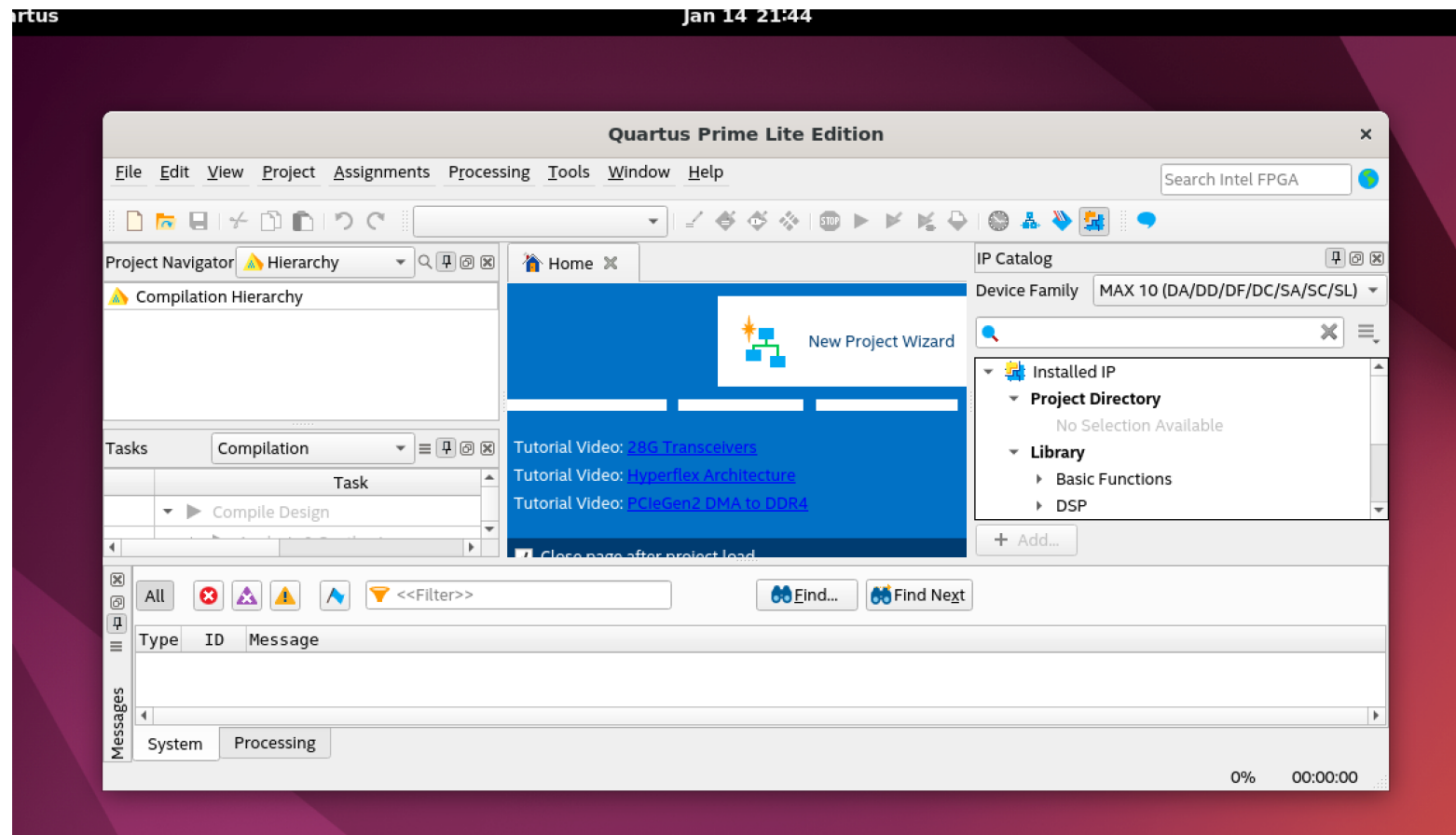


Open quartus in cloud 9 terminal

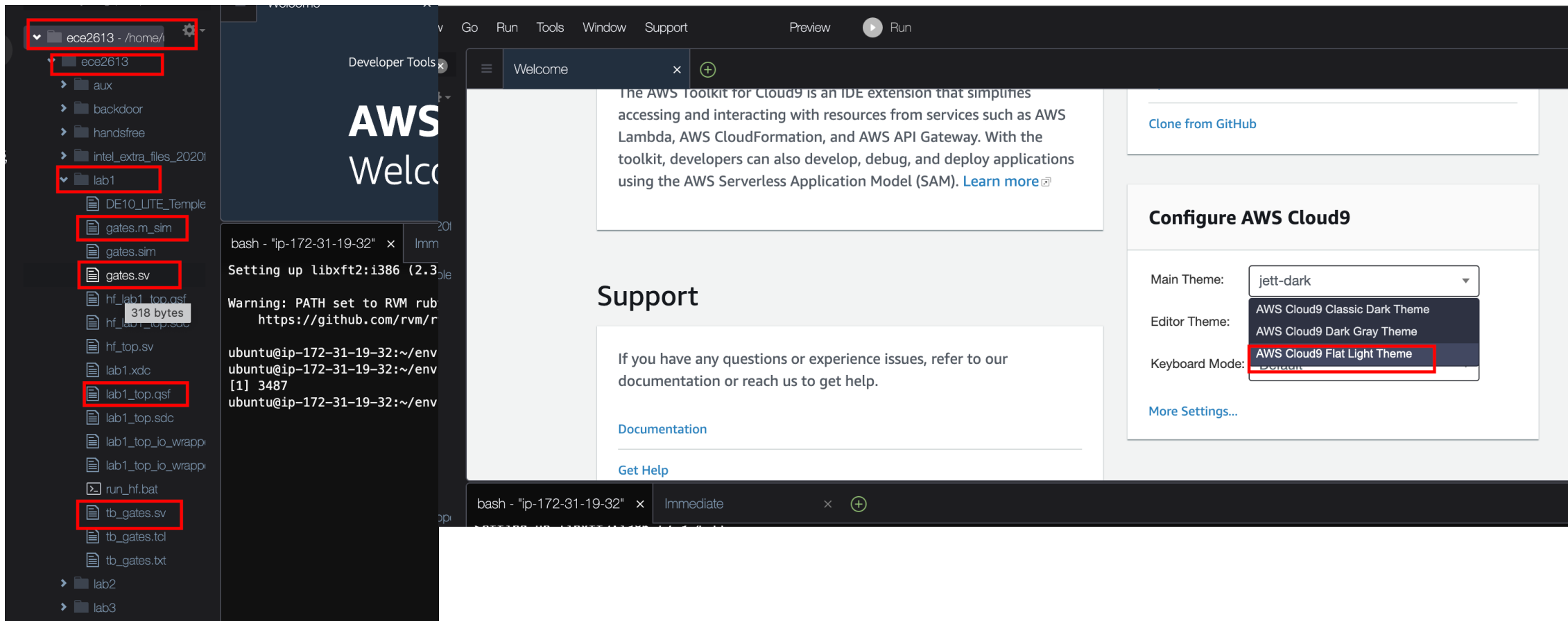
```
Setting up libxft2:i386 (2.3.4-1) ...  
  
Warning: PATH set to RVM ruby but GEM_HOME and/or GEM_PATH not set, see:  
https://github.com/rvm/rvm/issues/3212  
  
ubuntu@ip-172-31-19-32:~/environment$ export DISPLAY=:0  
ubuntu@ip-172-31-19-32:~/environment$ quartus &
```



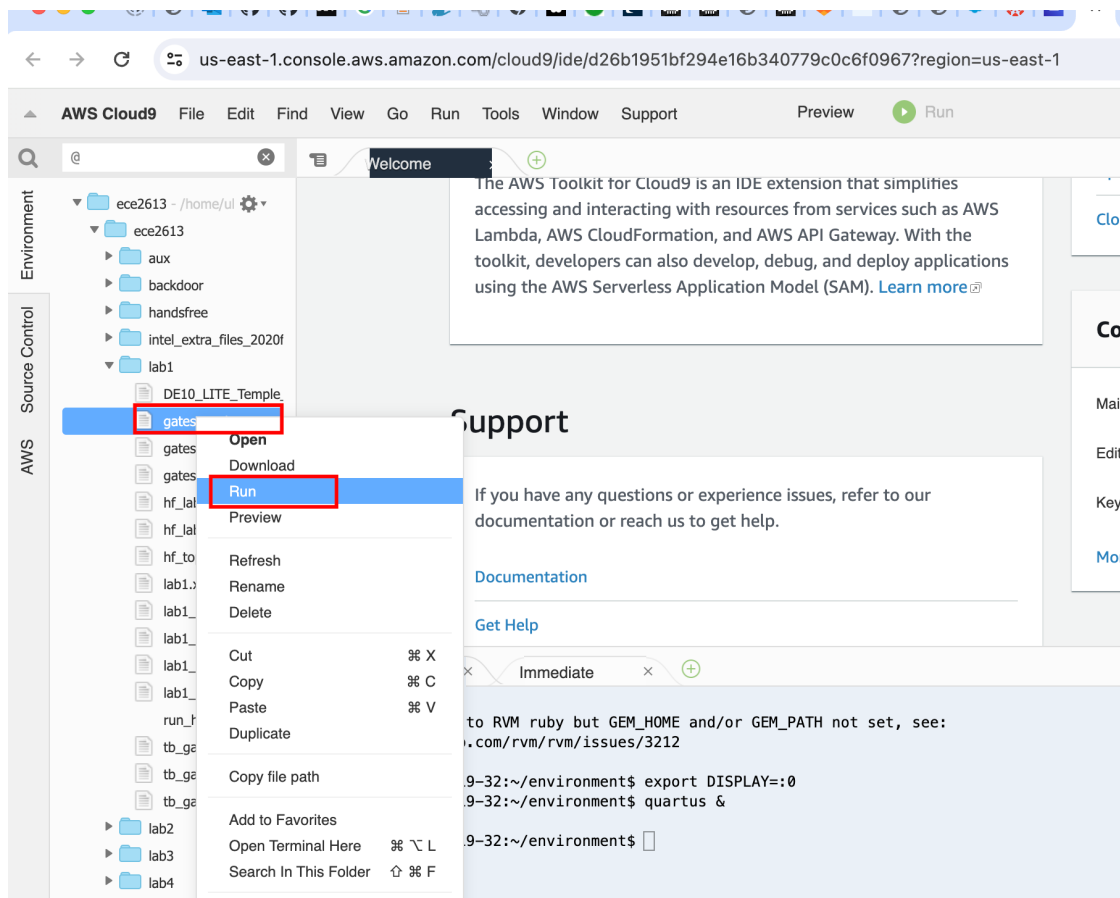
Quartus in xwindow



Cloud 9 file listing



Check m_sim file



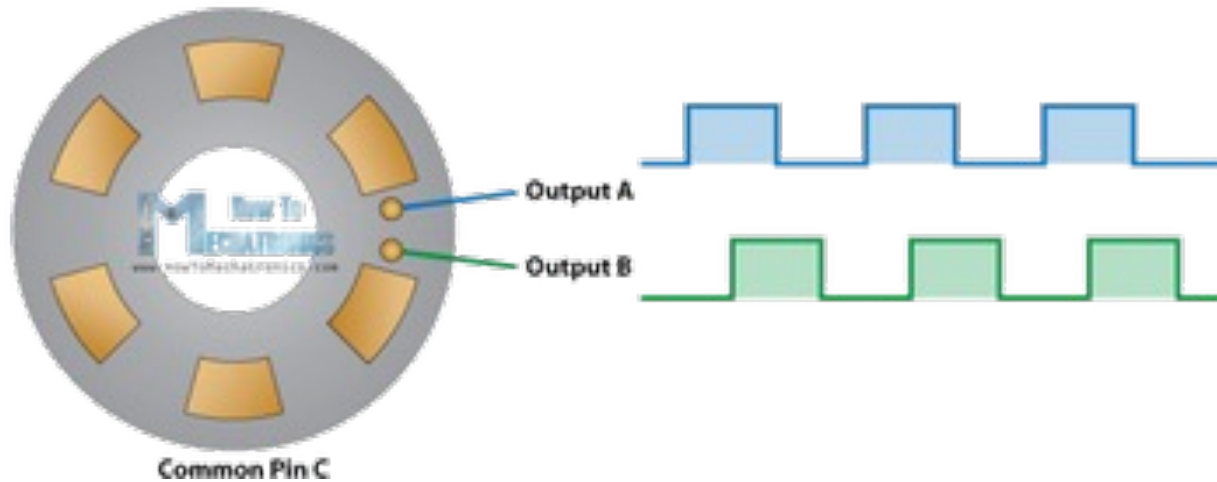
```
# Loading work.gates
# do gates.m_sim
# Mismatch--loop index i:      0; input: 00, expected: 1000, received: xxx>
# Mismatch--loop index i:      1; input: 01, expected: 1110, received: xxx>
# Mismatch--loop index i:      2; input: 10, expected: 1110, received: xxx>
# Mismatch--loop index i:      3; input: 11, expected: 0011, received: xxx>
# Simulation complete -      4 mismatches!!!
# ** Note: $finish      : tb_gates.sv(64)
#   Time: 80 ns Iteration: 0 Instance: /tb_gates
# End time: 21:48:13 on Jan 14,2024, Elapsed time: 0:00:00
# Errors: 0, Warnings: 0
```

Process exited with code: 0

For the next class...

- Think about how you would design a vendor machine with instruction...

Rotatory encoder – example for FPGA



Gate symbols



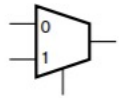
AND gate



OR gate



inverter



multiplexer

| A | B | AND | OR | XOR | Inverter (A) |
|---|---|-----|----|-----|--------------|
| 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 |

Vat example

EXAMPLE 1.1 Suppose a factory has two vats, only one of which is used at a time. The liquid in the vat in use needs to be at the right temperature, between 25°C and 30°C . Each vat has two temperature sensors indicating whether the temperature is above 25°C and above 30°C , respectively. The vats also have low-level sensors. The supervisor needs to be woken up by a buzzer when the temperature is too high or too low or the vat level is too low. He has a switch to select which vat is in use. Design a circuit of gates to activate the buzzer as required.

SOLUTION For the selected vat, the condition for activating the buzzer is

Solution

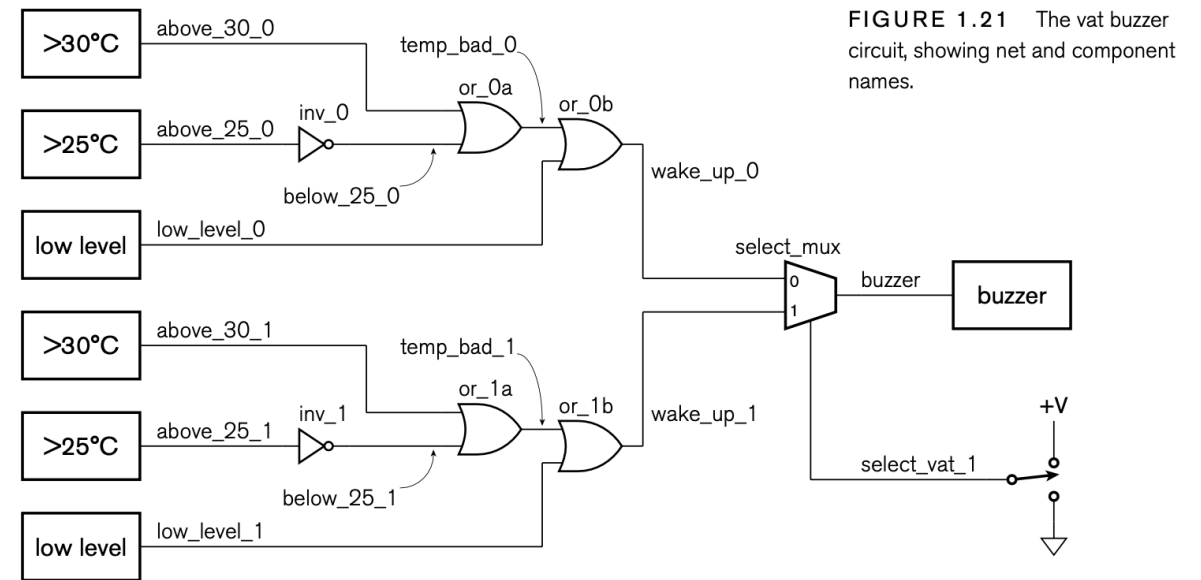
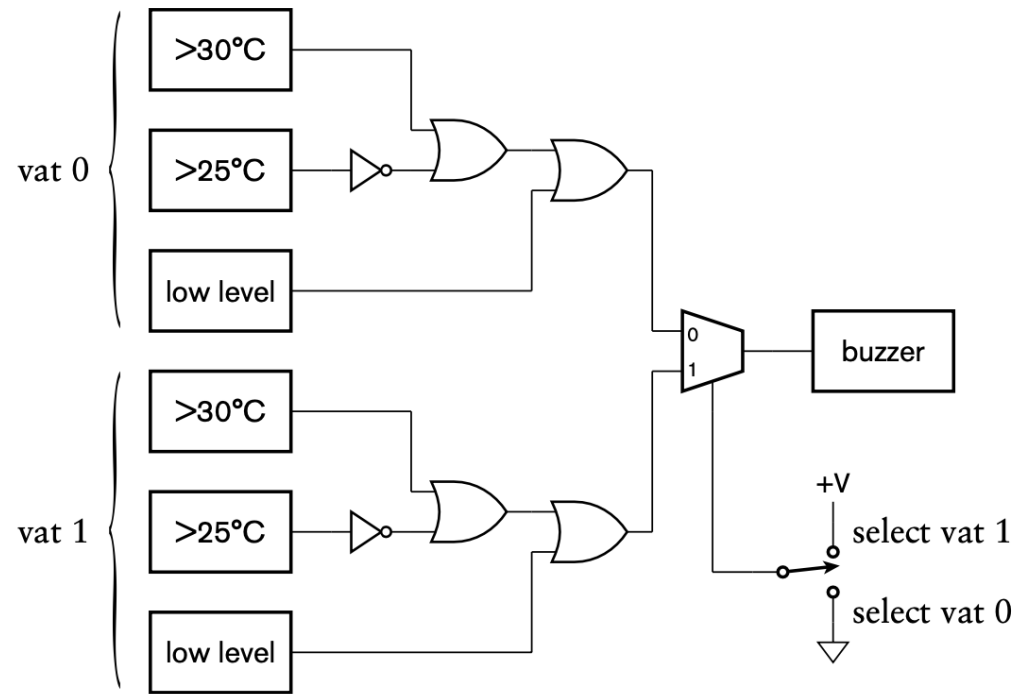


FIGURE 1.21 The vat buzzer circuit, showing net and component names.

Verilog

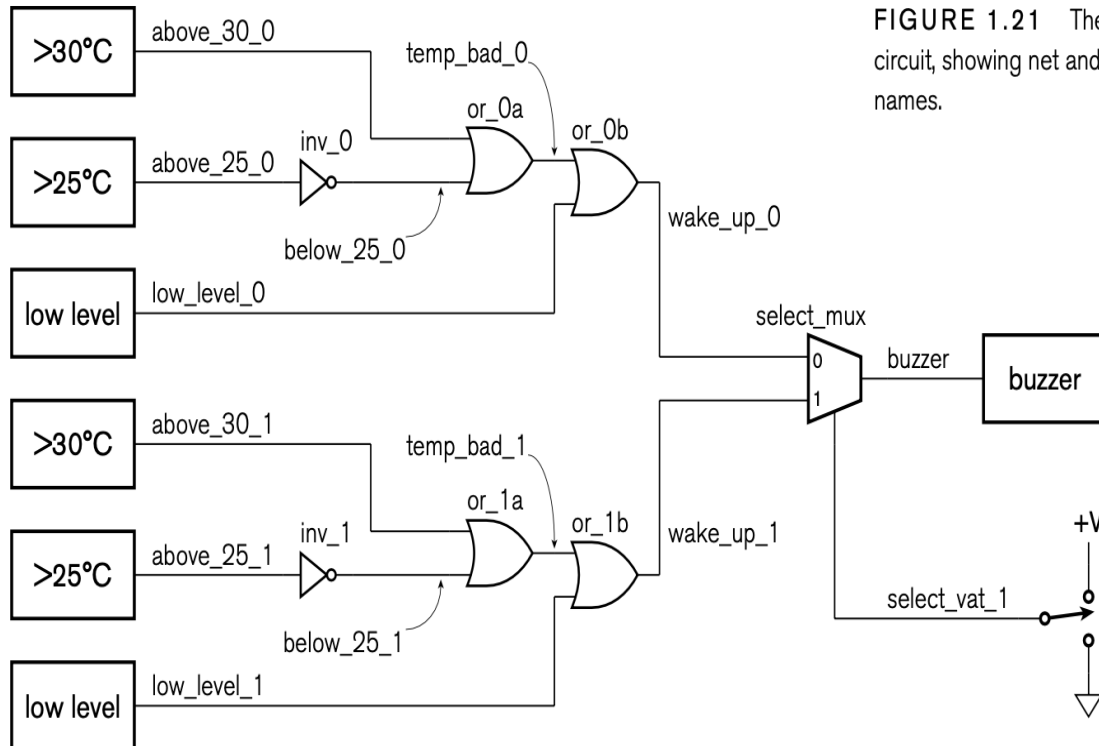


FIGURE 1.21 The vat buzzer circuit, showing net and component names.

```
module vat_buzzer_struct
( output buzzer,
  input above_25_0, above_30_0, low_level_0,
  input above_25_1, above_30_1, low_level_1,
  input select_vat_1 );

  wire below_25_0, temp_bad_0, wake_up_0;
  wire below_25_1, temp_bad_1, wake_up_1;

  // components for vat 0
  not inv_0 (below_25_0, above_25_0);
  or or_0a (temp_bad_0, above_30_0, below_25_0);
  or or_0b (wake_up_0, temp_bad_0, low_level_0);

  // components for vat 1
  not inv_1 (below_25_1, above_25_1);
  or or_1a (temp_bad_1, above_30_1, below_25_1);
  or or_1b (wake_up_1, temp_bad_1, low_level_1);

  mux2 select_mux (buzzer, select_vat_1, wake_up_0, wake_up_1);

endmodule
```

Block diagram and Verilog code

```
module vat_buzzer_struct
( output buzzer,
  input above_25_0, above_30_0, low_level_0,
  input above_25_1, above_30_1, low_level_1,
  input select_vat_1 );

wire below_25_0, temp_bad_0, wake_up_0;
wire below_25_1, temp_bad_1, wake_up_1;

// components for vat 0
not inv_0 (below_25_0, above_25_0);
or or_0a (temp_bad_0, above_30_0, below_25_0);
or or_0b (wake_up_0, temp_bad_0, low_level_0);

// components for vat 1
not inv_1 (below_25_1, above_25_1);
or or_1a (temp_bad_1, above_30_1, below_25_1);
or or_1b (wake_up_1, temp_bad_1, low_level_1);

mux2 select_mux (buzzer, select_vat_1, wake_up_0, wake_up_1);

endmodule
```

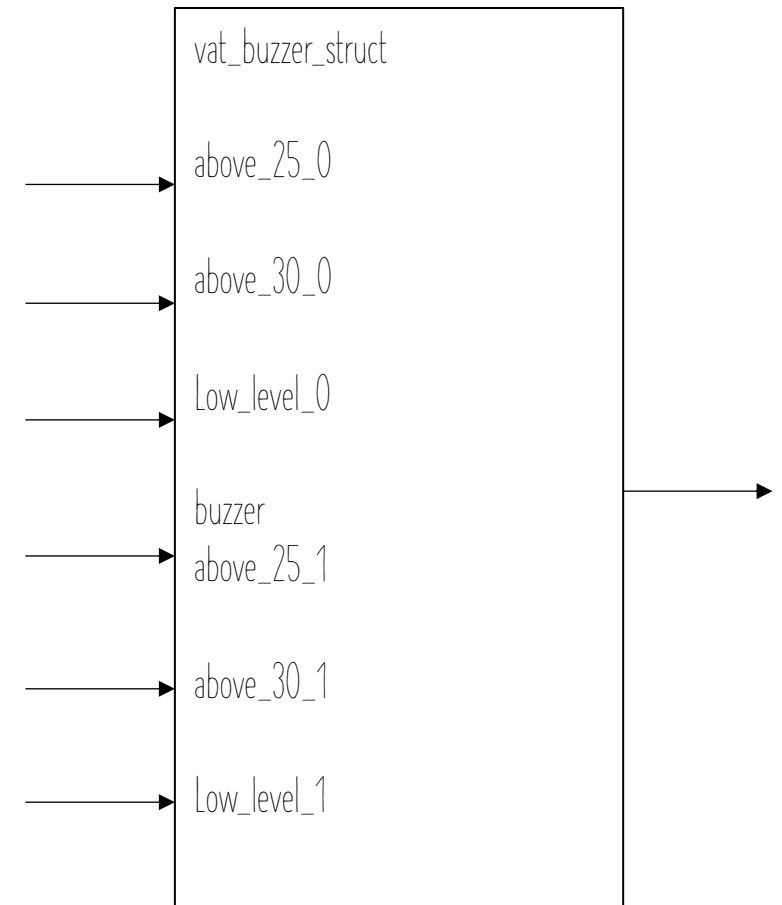
```
module vat_buzzer_behavior
( output buzzer,
  input  above_25_0, above_30_0, low_level_0,
  input  above_25_1, above_30_1, low_level_1,
  input  select_vat_1 );

assign buzzer =
  select_vat_1 ? low_level_1 | (above_30_1 | ~above_25_1)
               : low_level_0 | (above_30_0 | ~above_25_0);

endmodule
```

use gate primitive

use logic behavior



Soda vending machine

- Suppose a soda vending machine has two choices of soda, only one of which is dispensed at a time. The soda in the chosen slot needs to have the right cost, between \$2 and \$3. Each slot has two cost sensors indicating whether the cost is above \$3 and above \$20, respectively. The slots also have zero-level sensors. The supervisor needs to be notified by a dispenser when the cost is too high or too low, or the soda level is too low. They have a switch to select which soda slot is in use. Design a circuit of gates to activate the dispenser as required.

Timing Diagram

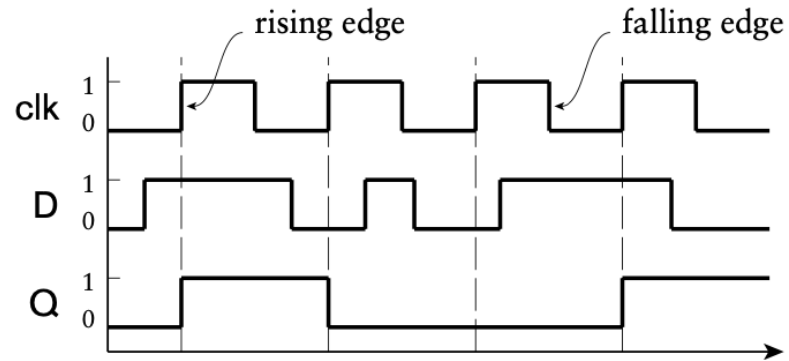


FIGURE 1.7 Timing diagram for a D flip-flop.

EXERCISE 1.6 Complete the timing diagram in Figure 1.25, showing the operation of a rising-edge-triggered D flip-flop.

