DATA 442: Neural Networks & Deep Learning

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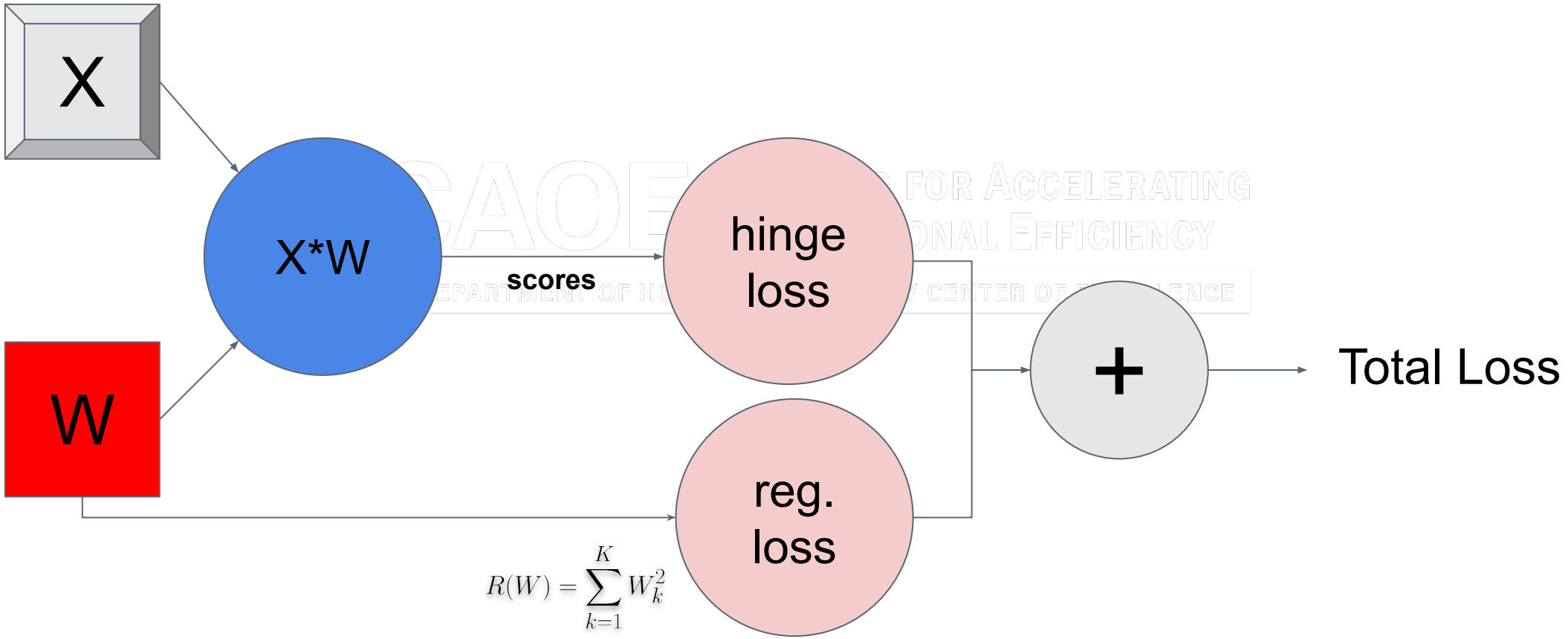
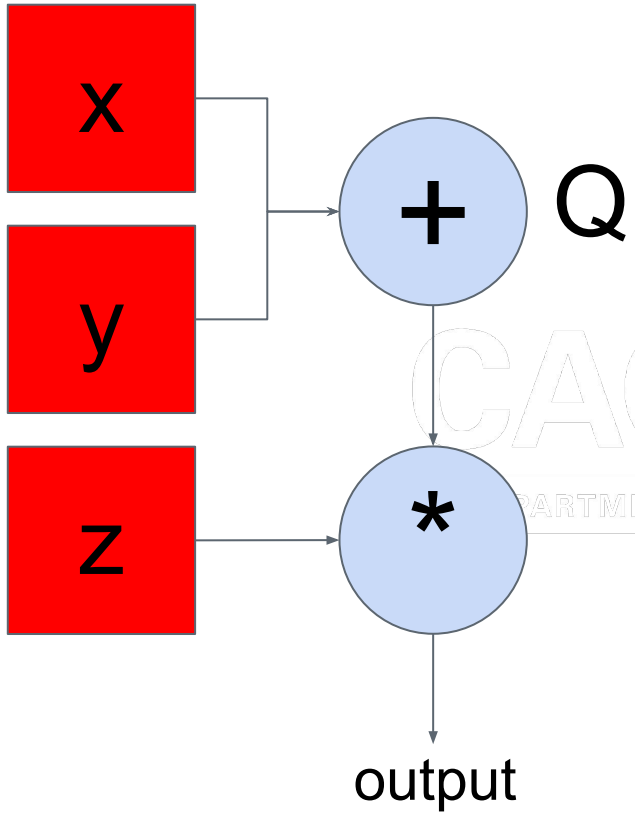
icss.wm.edu/data442/

$$f(X, W)$$

$$\sum_{j \neq y_i}^{J} max(0, s_j - s_{y_i} + \varepsilon)$$

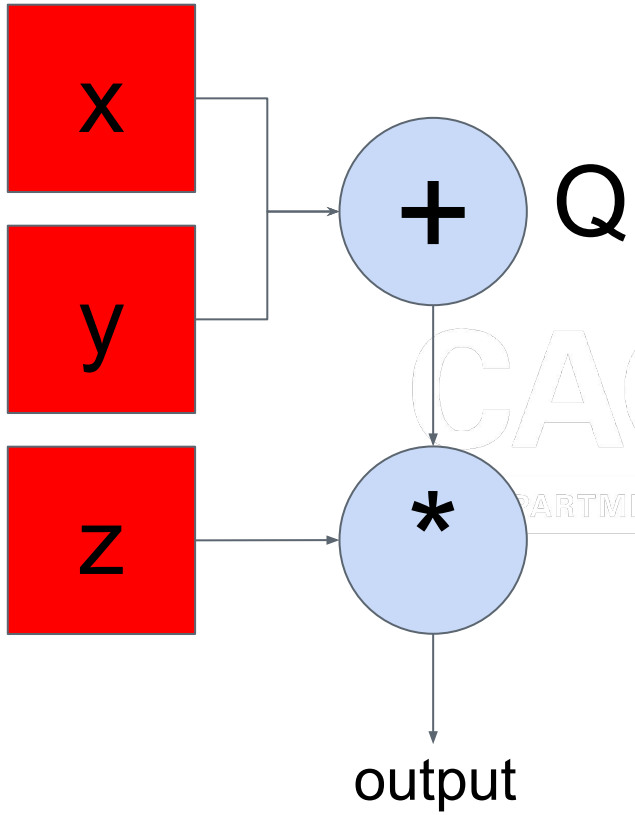


$$f(x, y, z) = (x + y) * z$$



$$Q = x + y$$

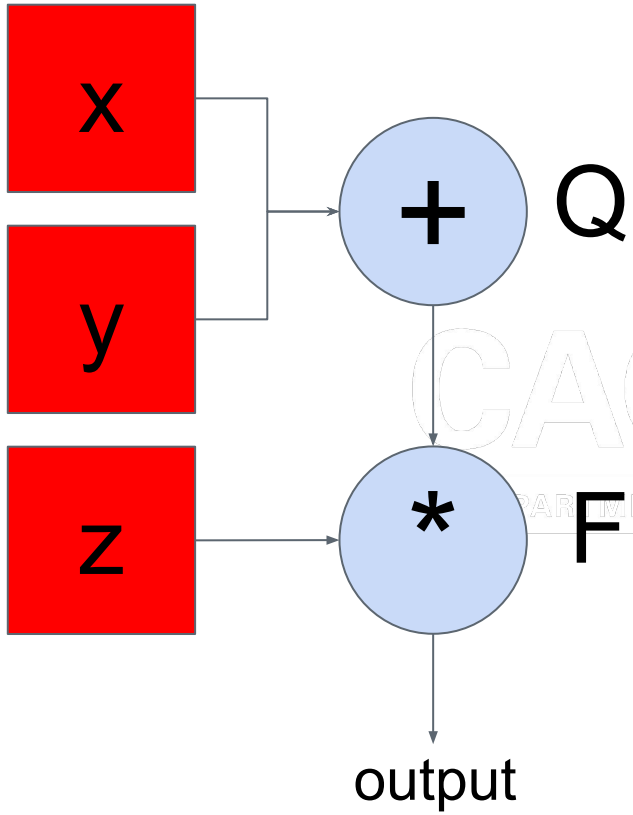
$$f(x, y, z) = (x + y) * z$$



$$Q = x + y$$

$$\frac{\partial q}{\partial x} = 1 \qquad \frac{\partial q}{\partial y} = 1$$

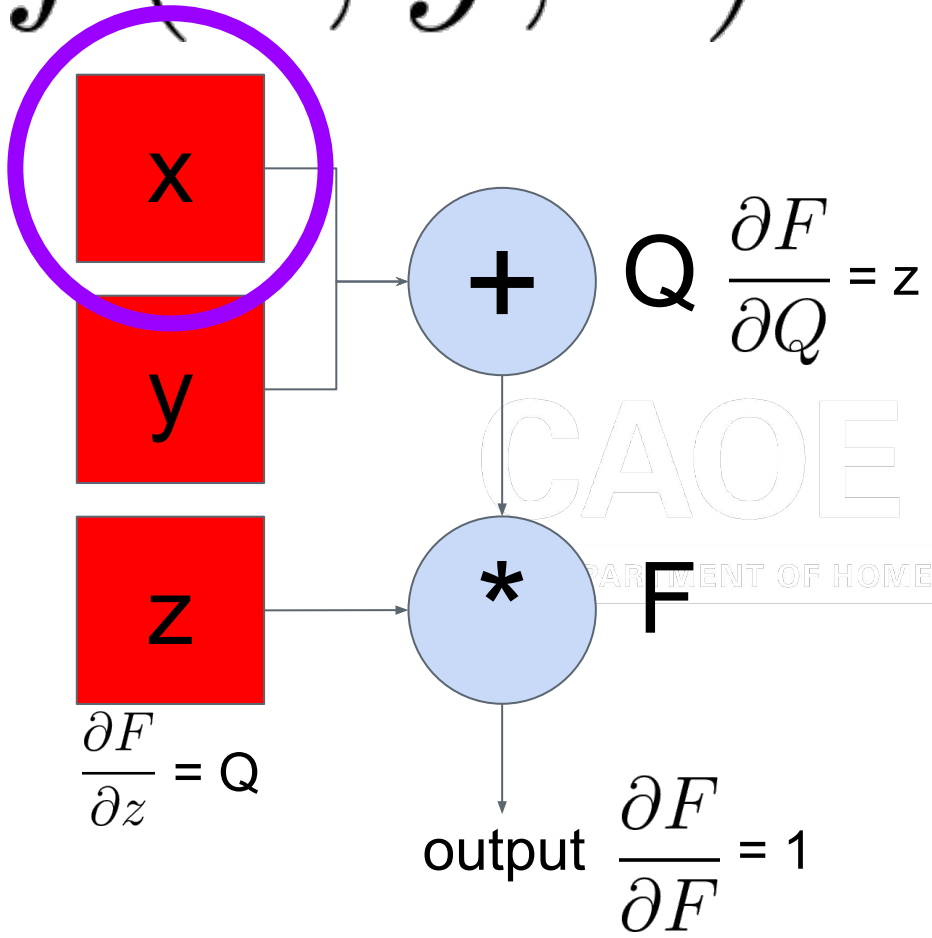
$$f(x, y, z) = (x + y) * z$$



$$F = qz$$

$$\frac{\partial f}{\partial Q} = z \quad \frac{\partial f}{\partial z} = Q$$

$$f(x, y, z) = (x + y) * z$$

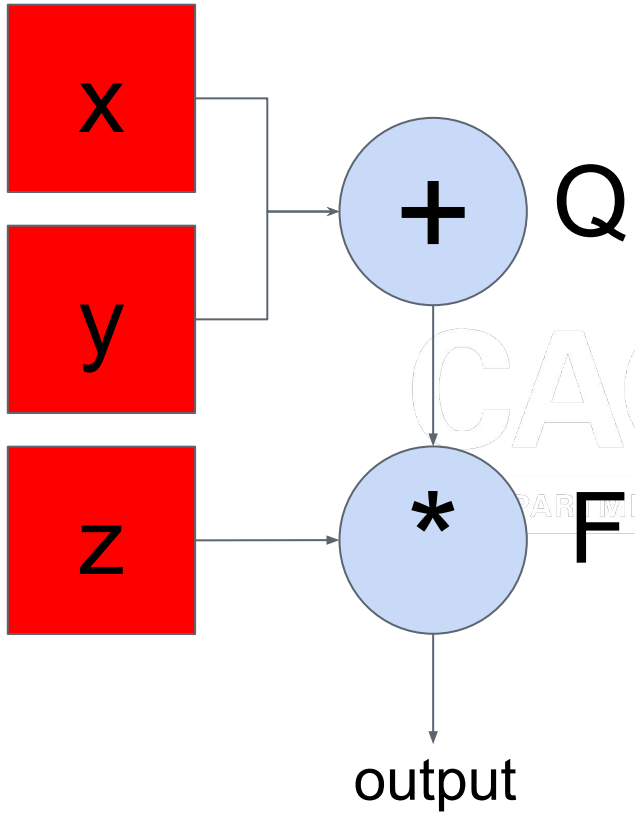


$$\frac{\partial F}{\partial x} = \frac{\partial F}{\partial q}\frac{\partial Q}{\partial x}$$

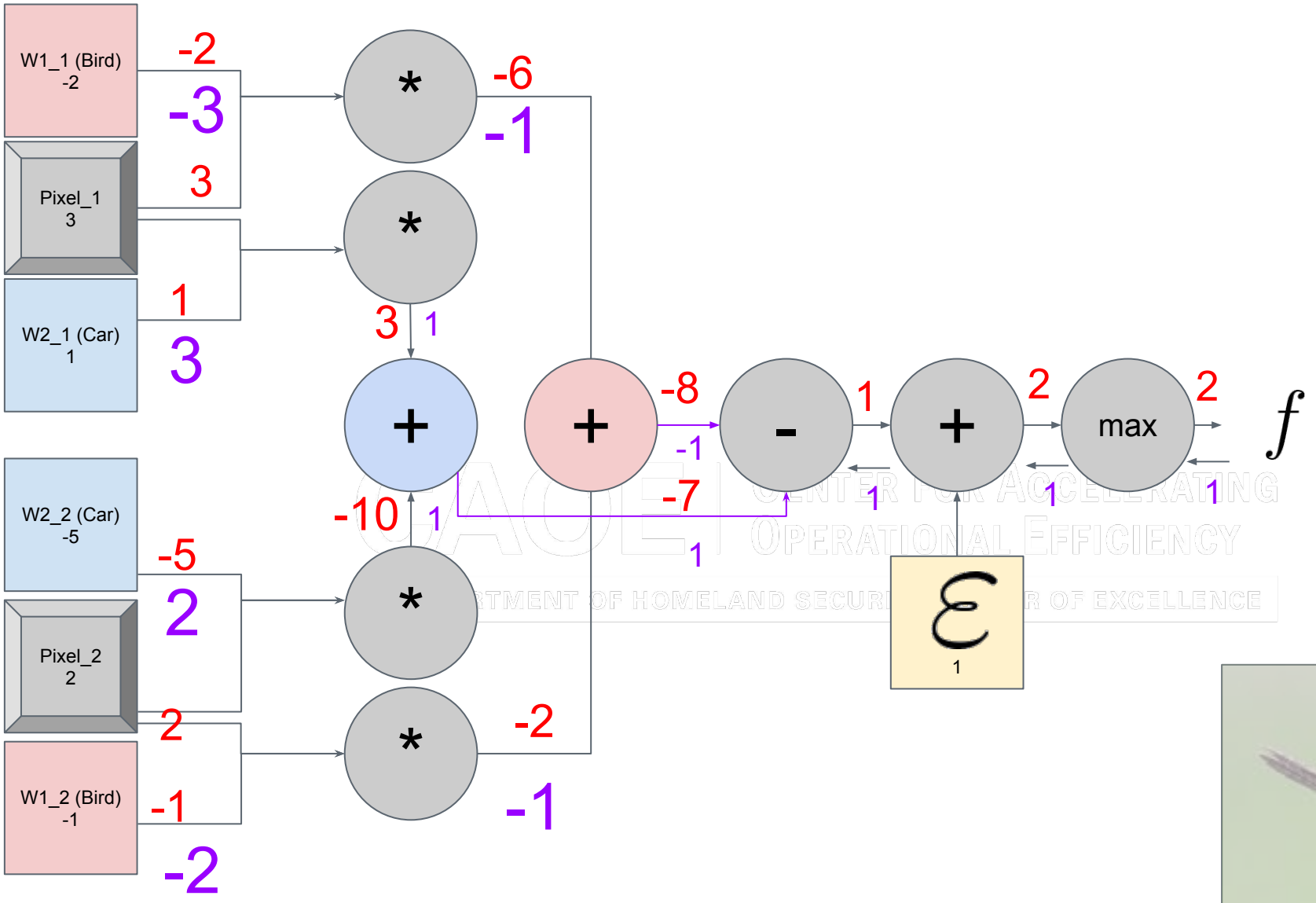
The Goal

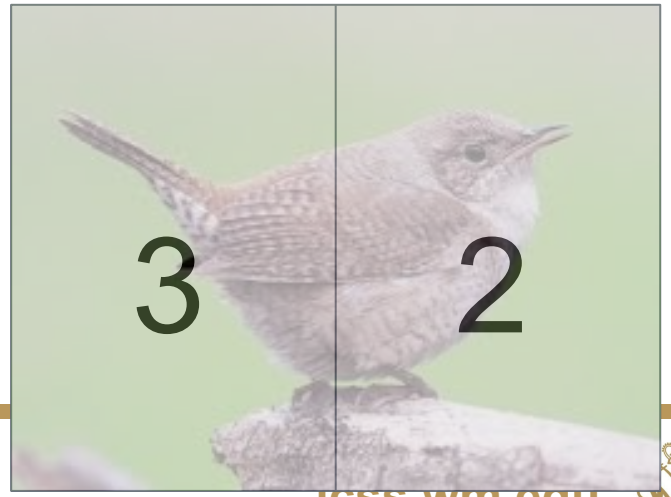
$$\frac{\partial F}{\partial x} \quad \frac{\partial F}{\partial y} \quad \frac{\partial F}{\partial z}$$

$$f(x, y, z) = (x + y) * z$$

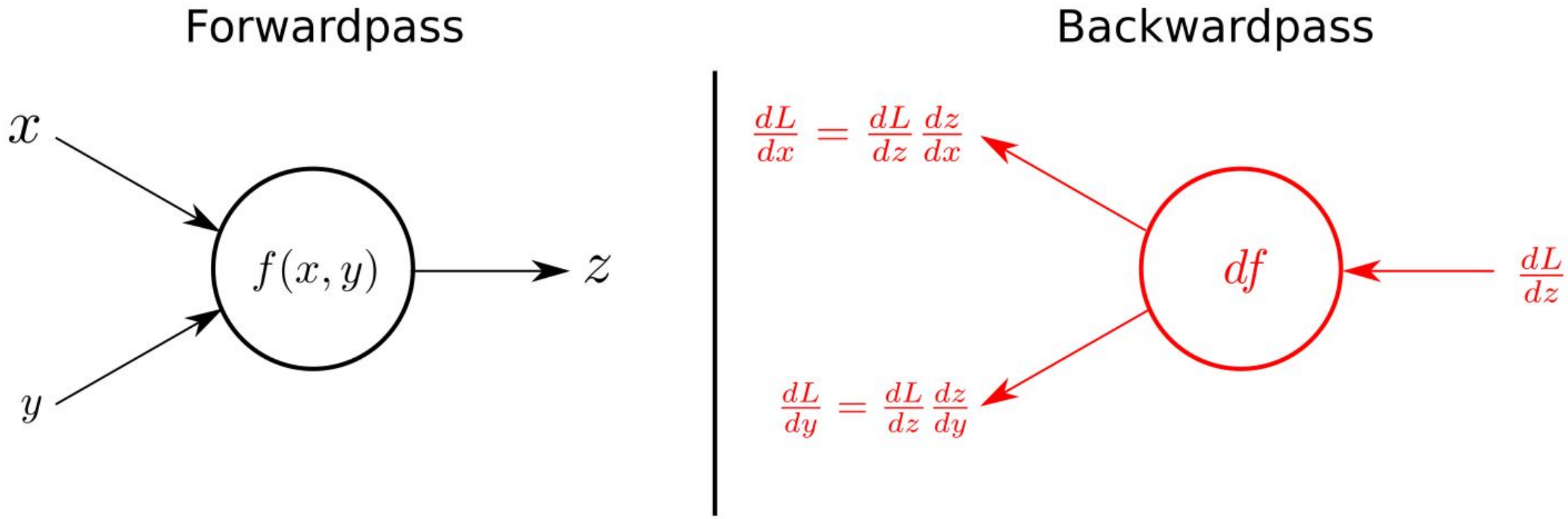


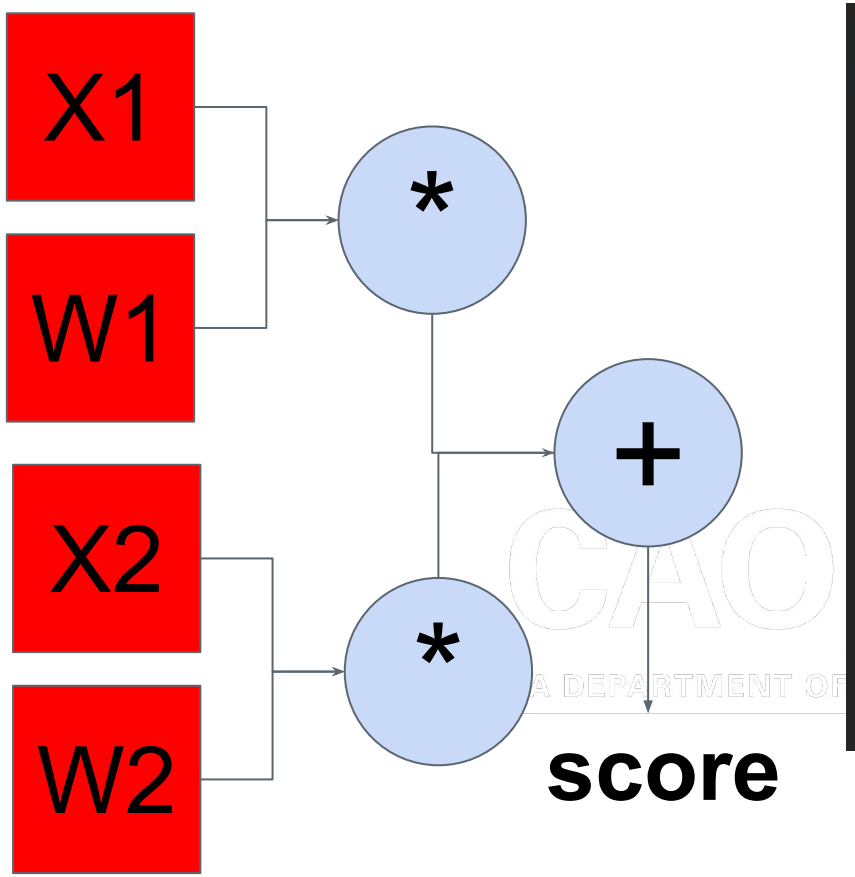
$$\frac{\partial F}{\partial x} = z * 1$$





Forward vs. Backward Pass

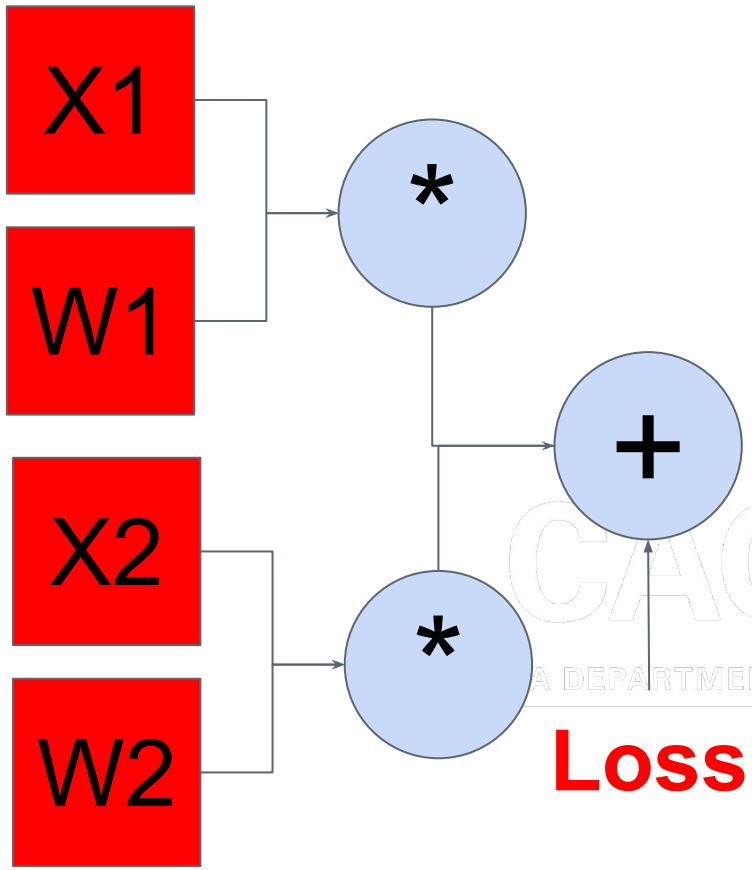





```
class simpleNeuralNetwork():
    def forwardPass(W,X):
        for node in computationalGraph:
            node.calculation()
        return totalLoss

    def backwardPass():
        for node in computationalGraph.flip():
            node.gradients()

        return W_and_X_gradients
```

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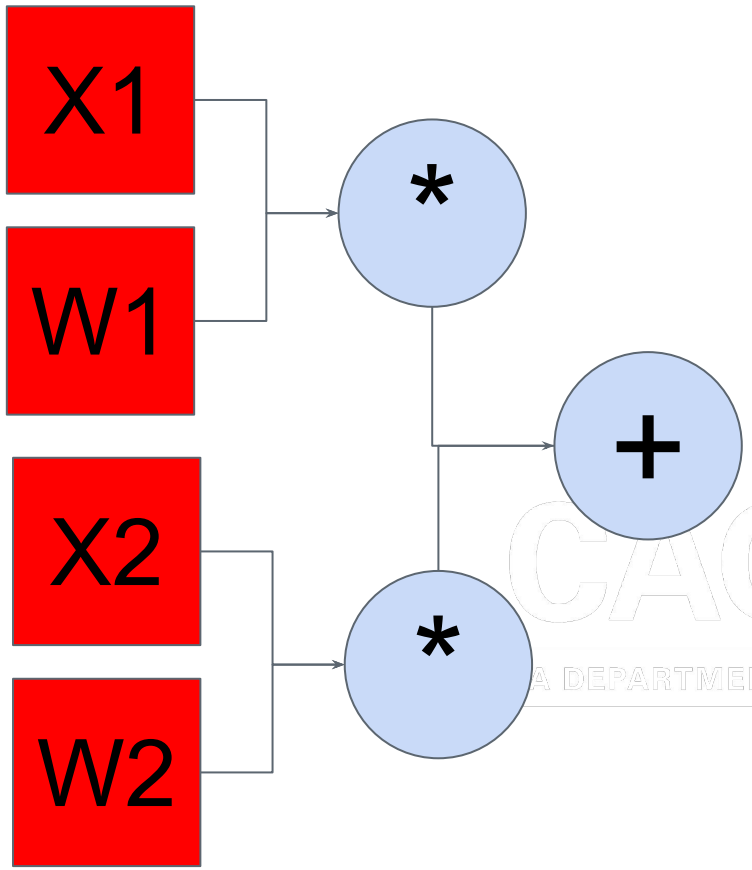
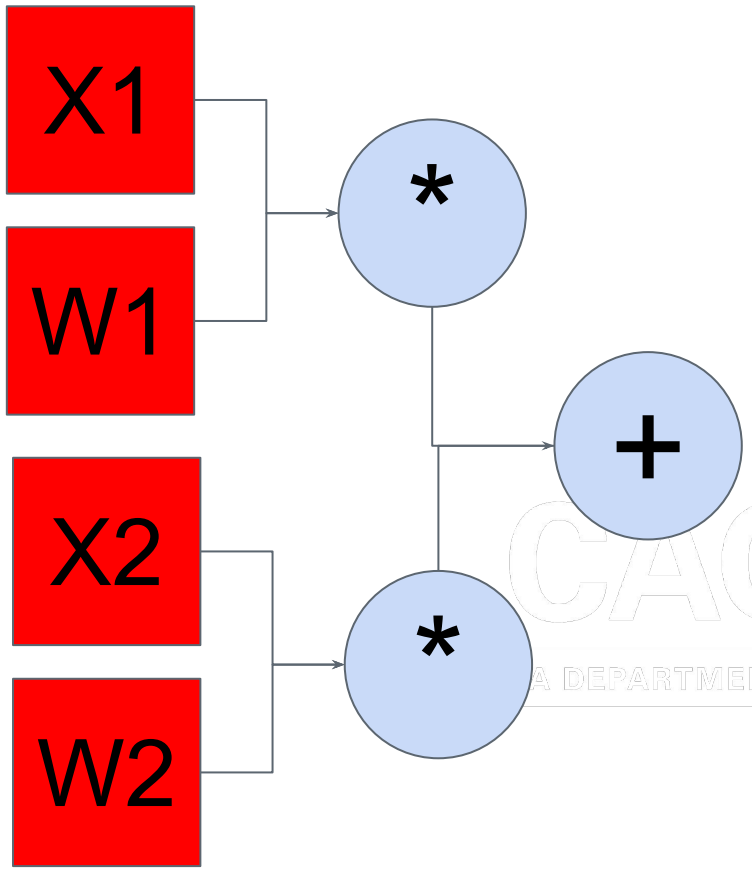
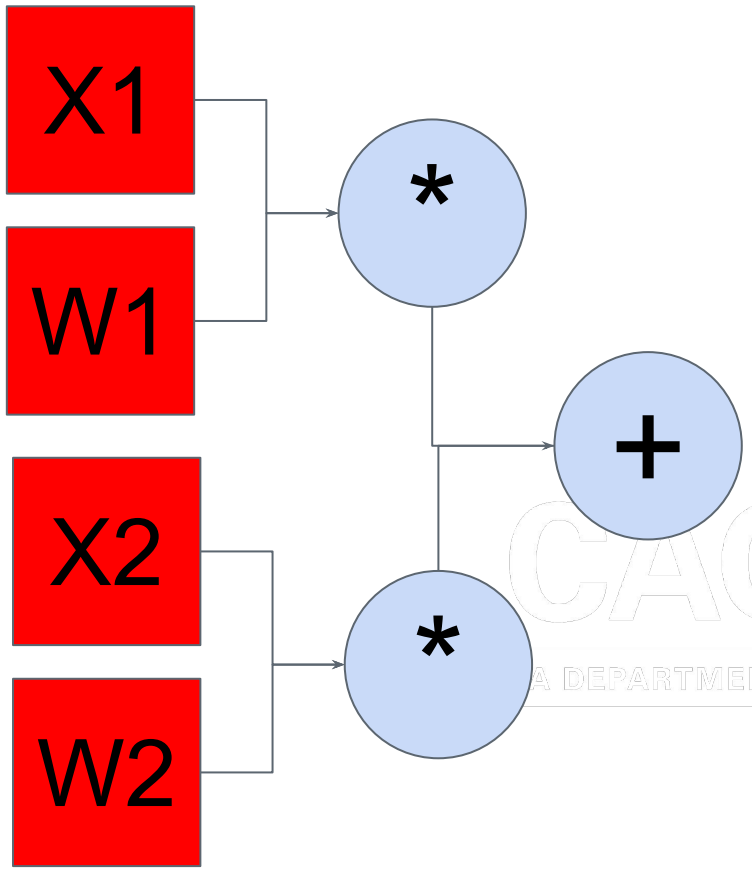





```
class MultiplicationNode():
    def forwardPass(W,X):
        output = X * W
        return output
```

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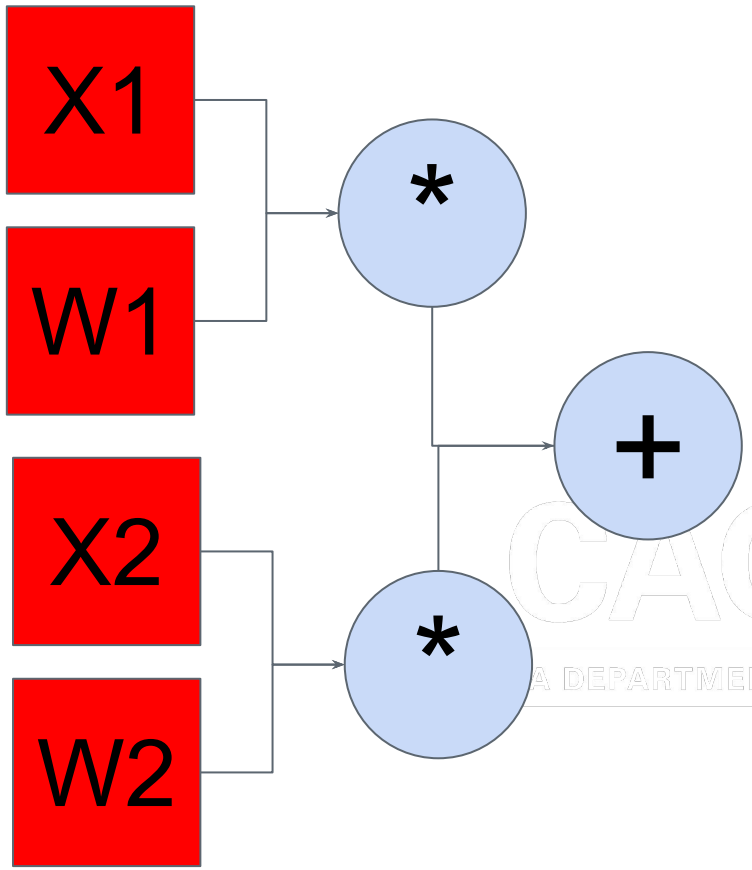


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class MultiplicationNode():
    def forwardPass(input1,input2):
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    def backwardPass(dOutput):
        dInput1 = ...
        dInput2 = ...
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```

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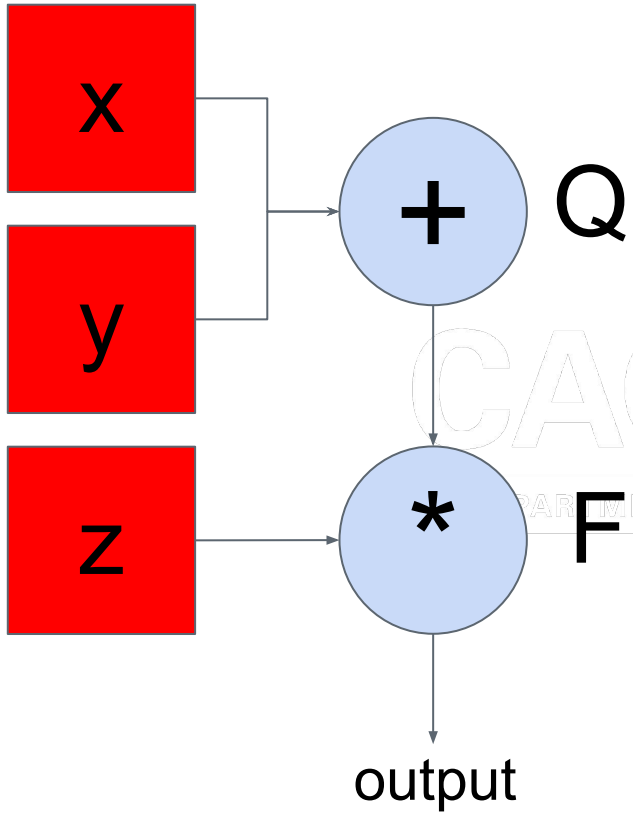

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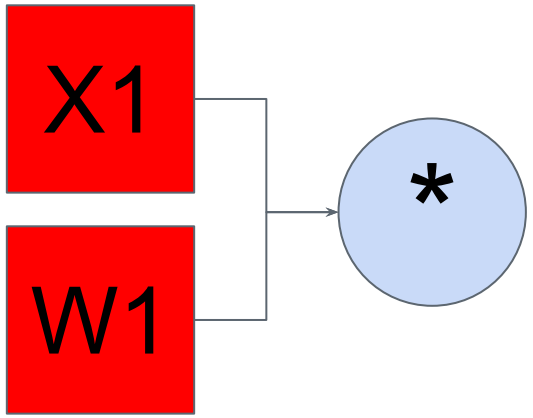


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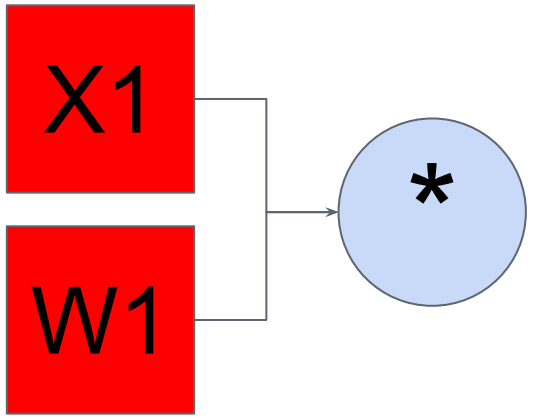


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```
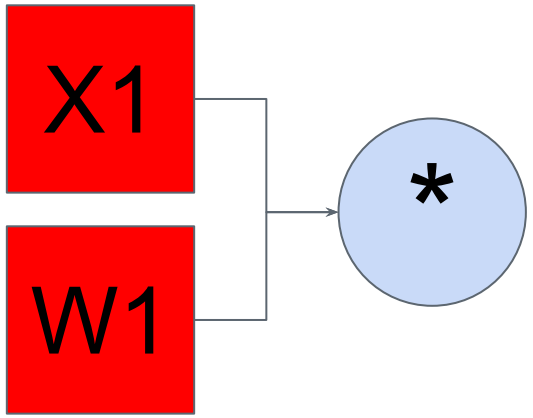
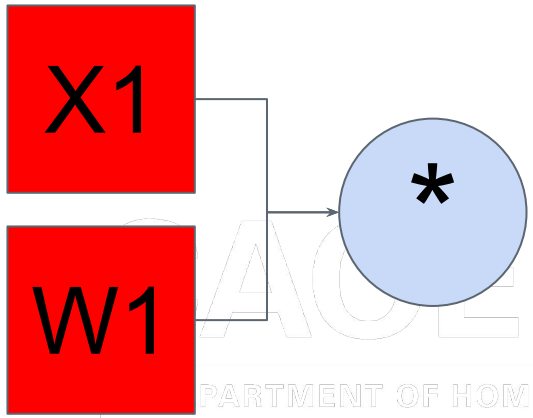



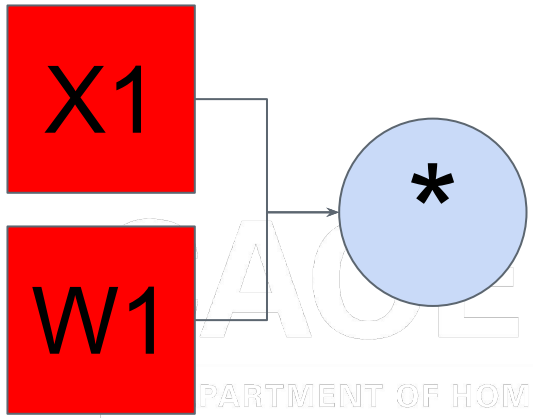

```
class MultiplicationNode():
    def forwardPass(input1,input2):
        output = input1 * input2
        self.input1 = input1
        self.input2 = input2
        return output

    def backwardPass(dOutput):
        dInput1 = self.input2 * dOutput
        dInput2 = self.input1 * dOutput
        return [dInput1, dInput2]
```

From Computational Graphs to Neural Nets



$$f(X, W) = X * W$$

From Computational Graphs to Neural Nets



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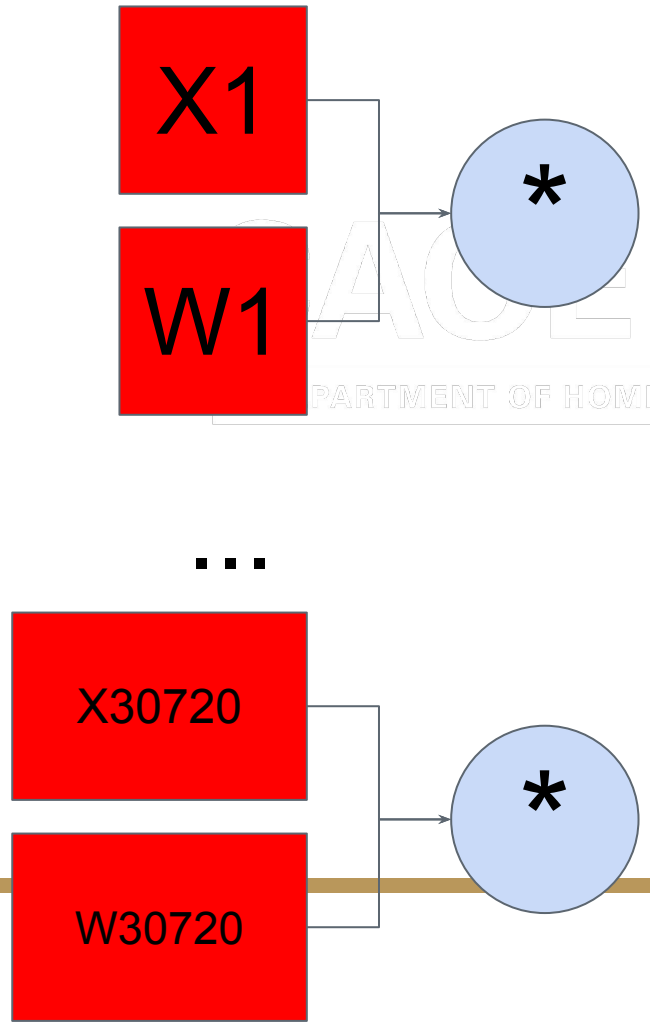
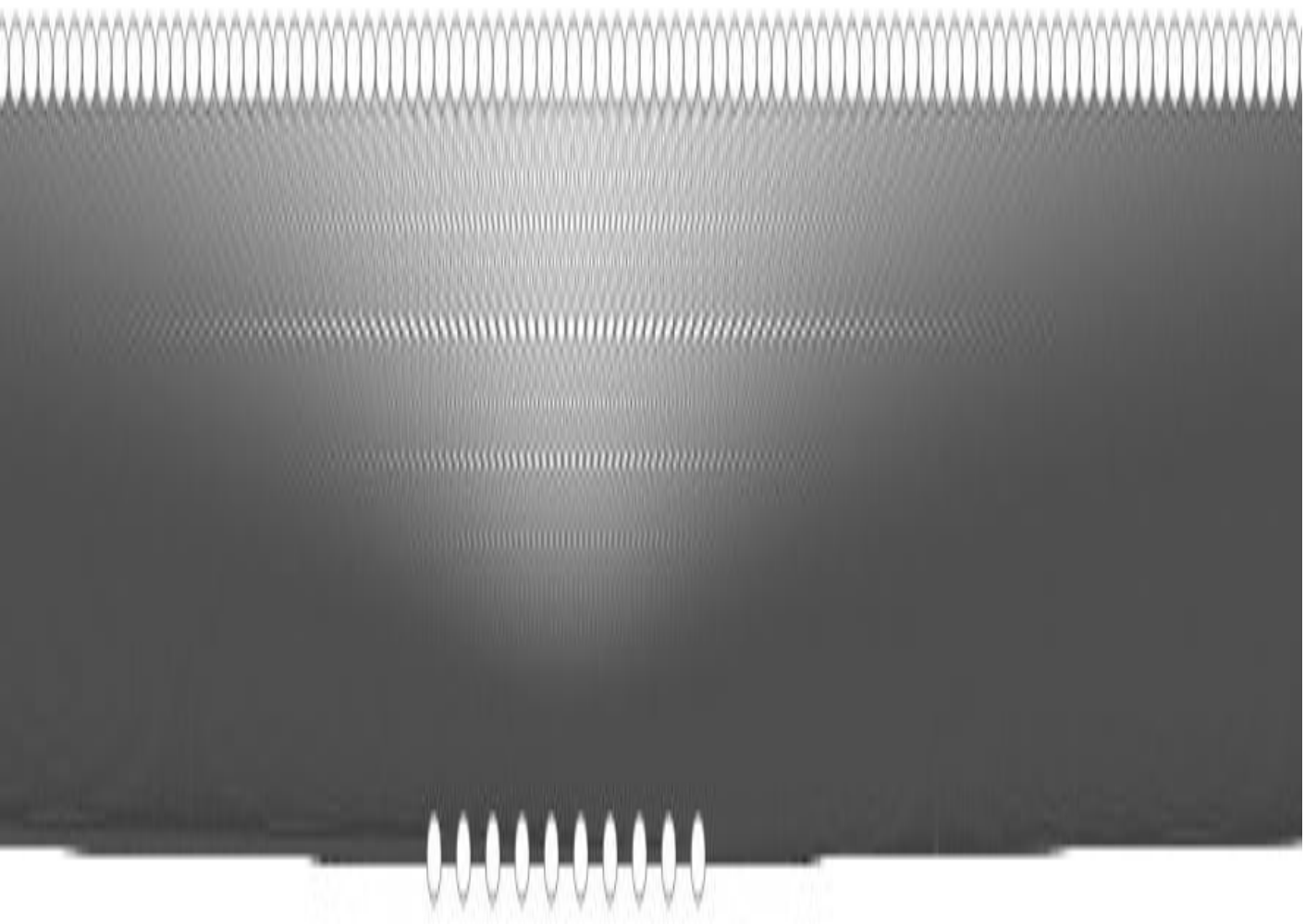
3,072 Pixels in CIFAR-10 (32x32x3 colors)

3,072 Weights for each of 10 classes.

From Computational Graphs to Neural Nets





From Computational Graphs to Neural Nets

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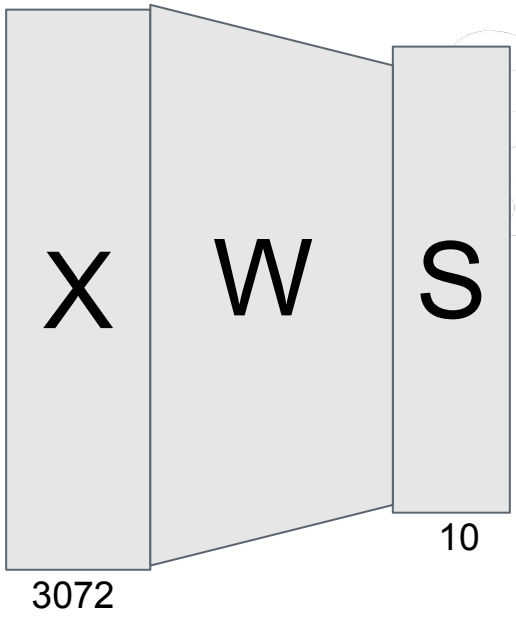
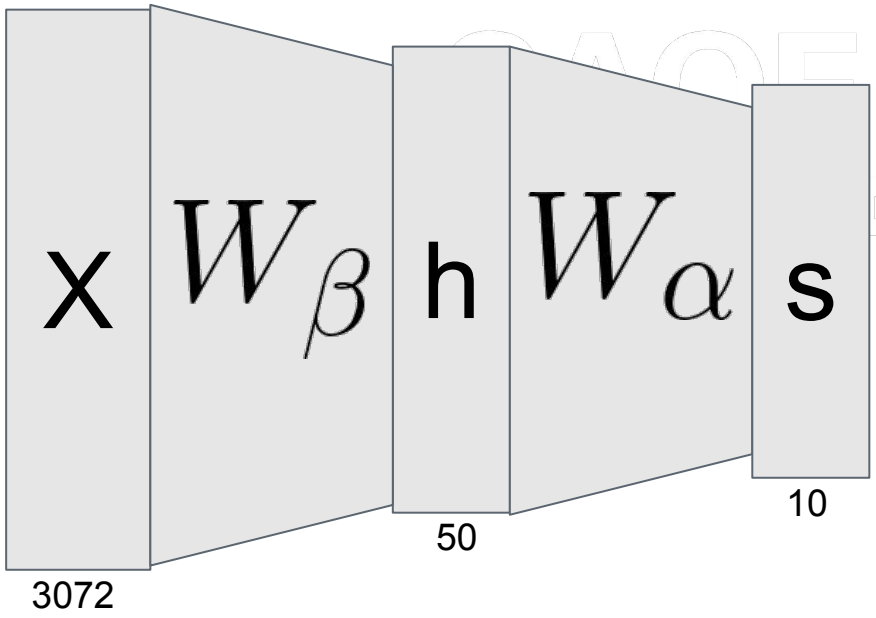


From Computational Graphs to Neural Nets

$$f = W_\alpha * max(0, W_\beta * X)$$



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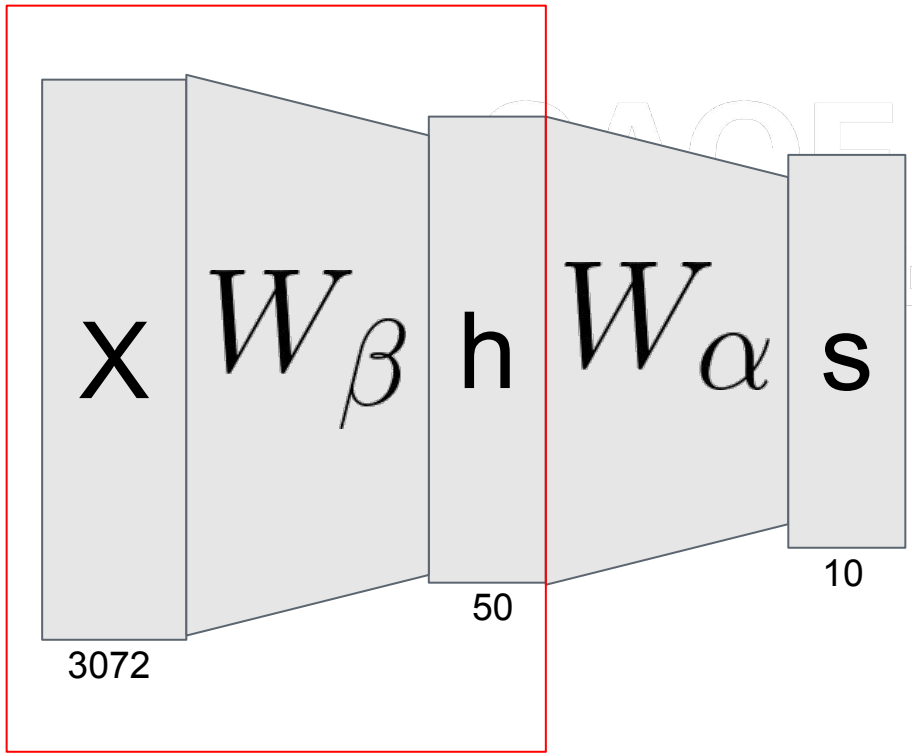

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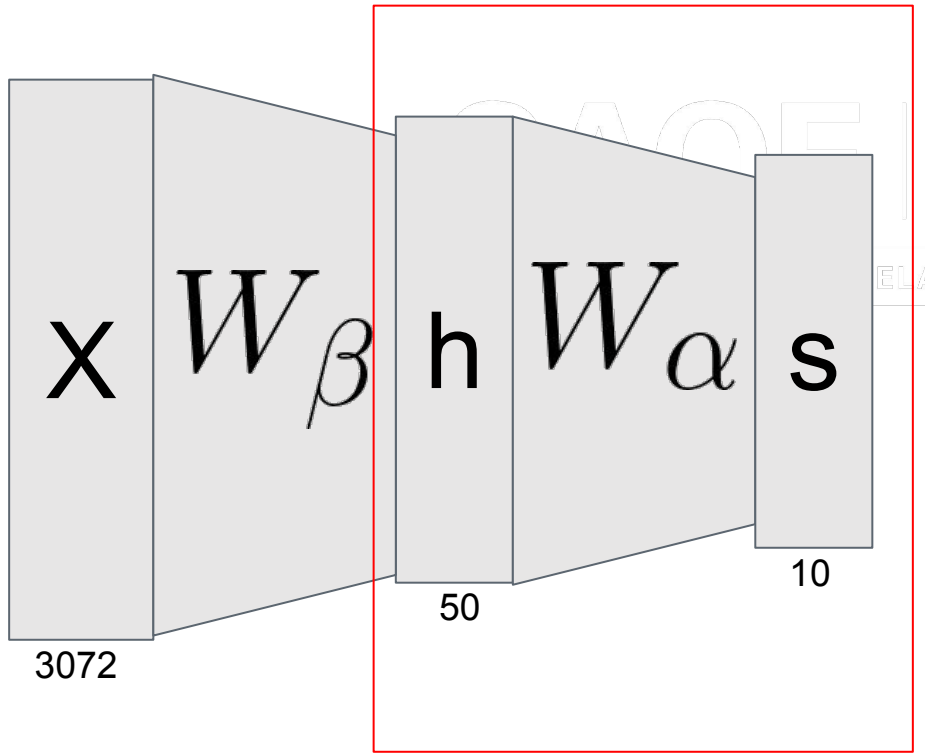

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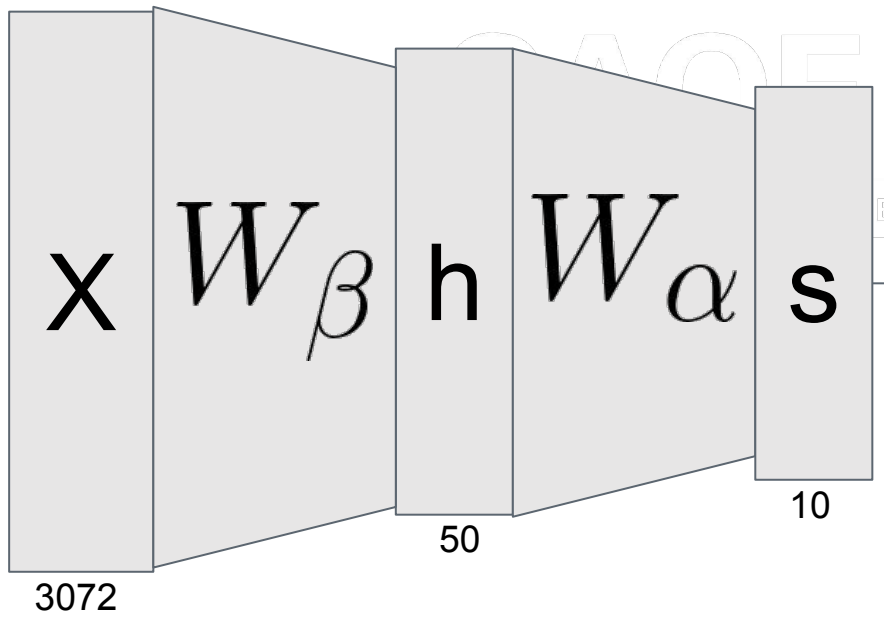
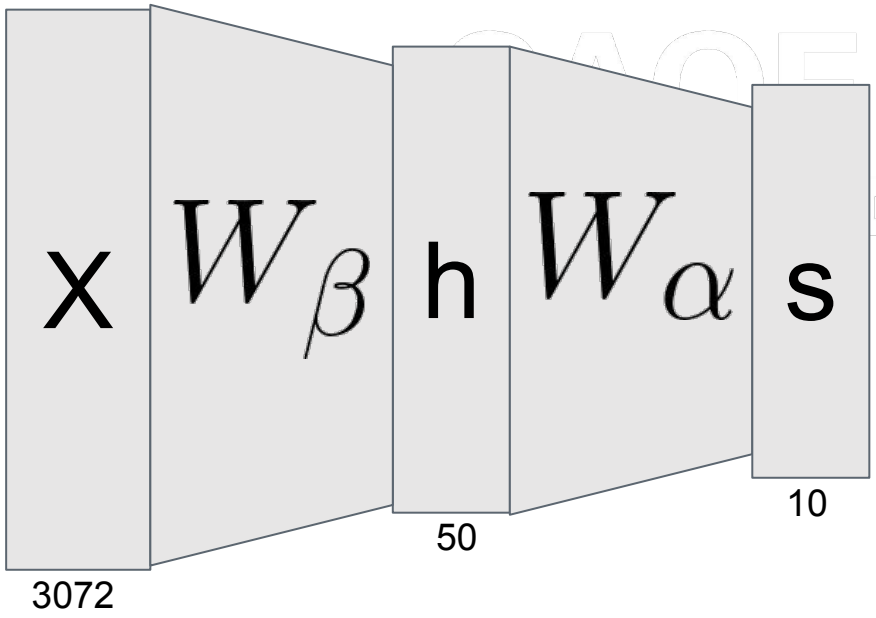


Loss Function

$$f = W_\alpha * max(0, W_\beta * X)$$



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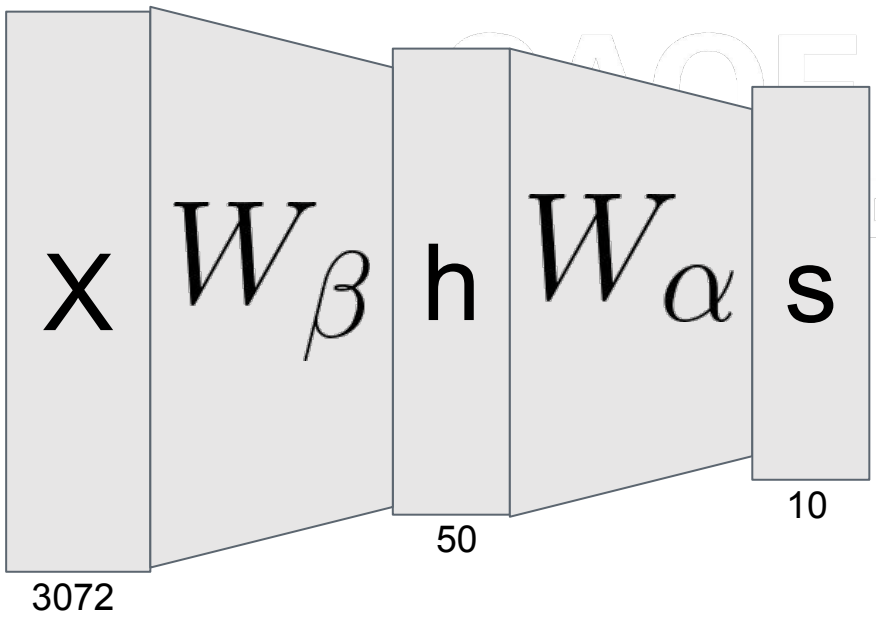

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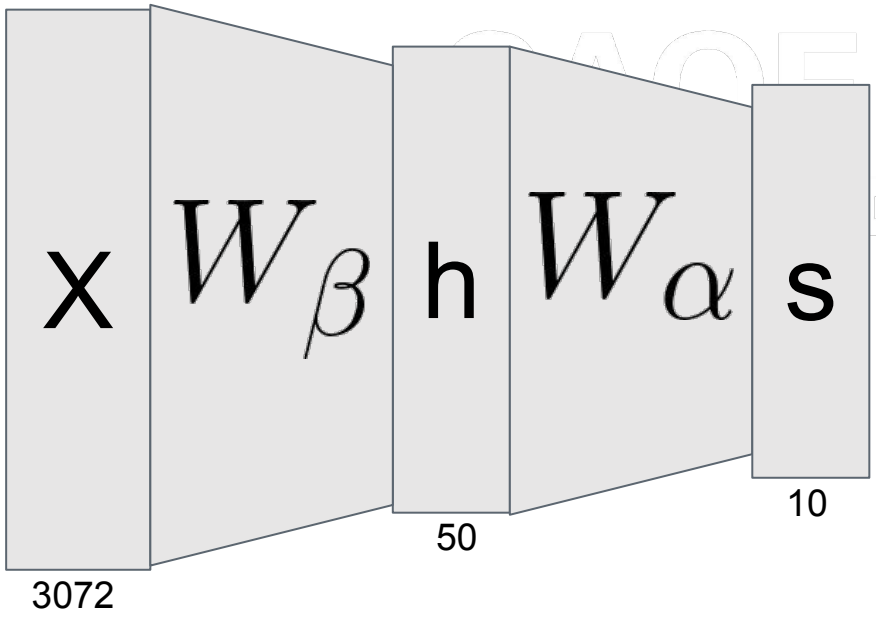

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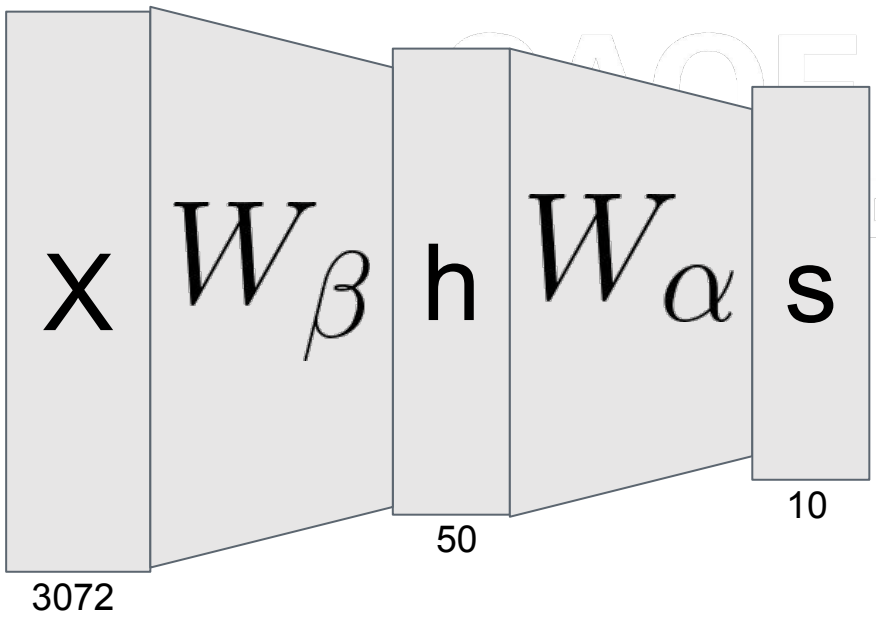

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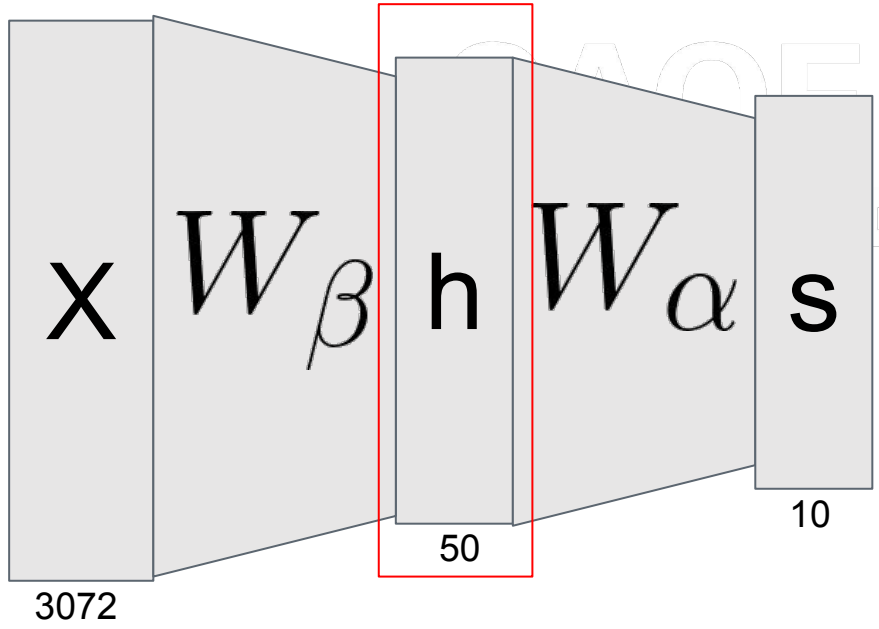
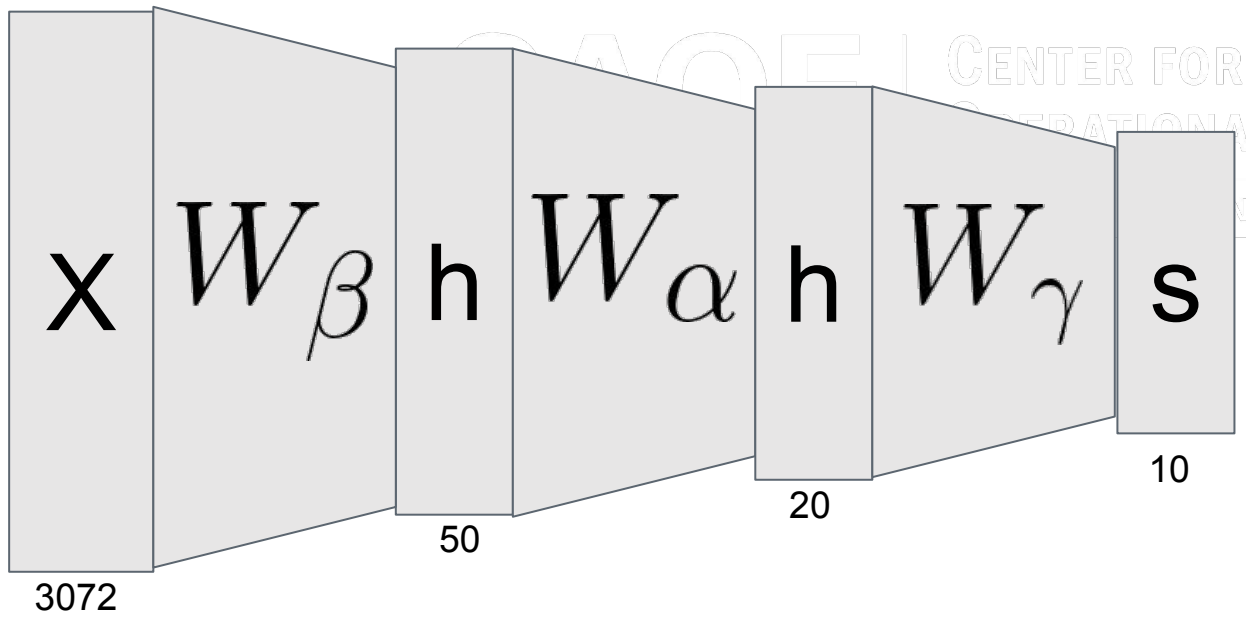
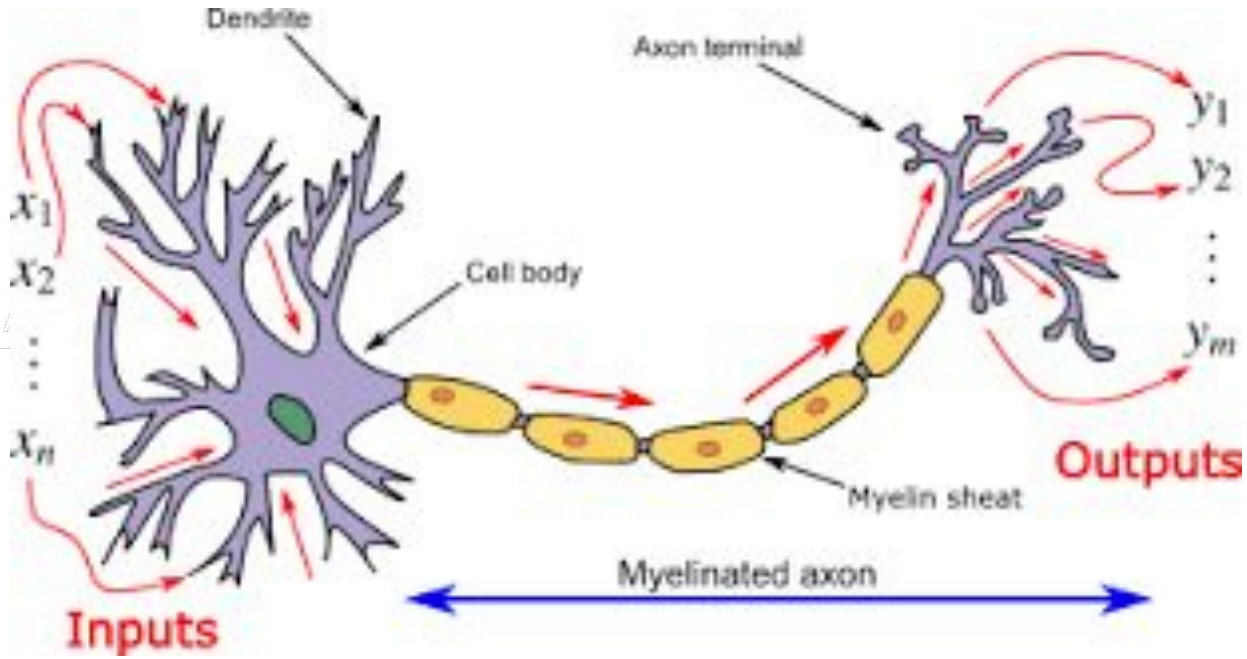
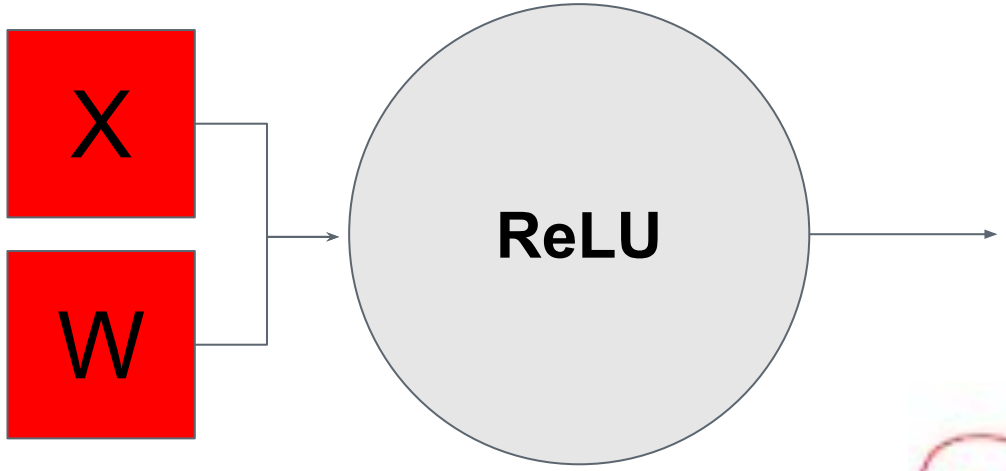
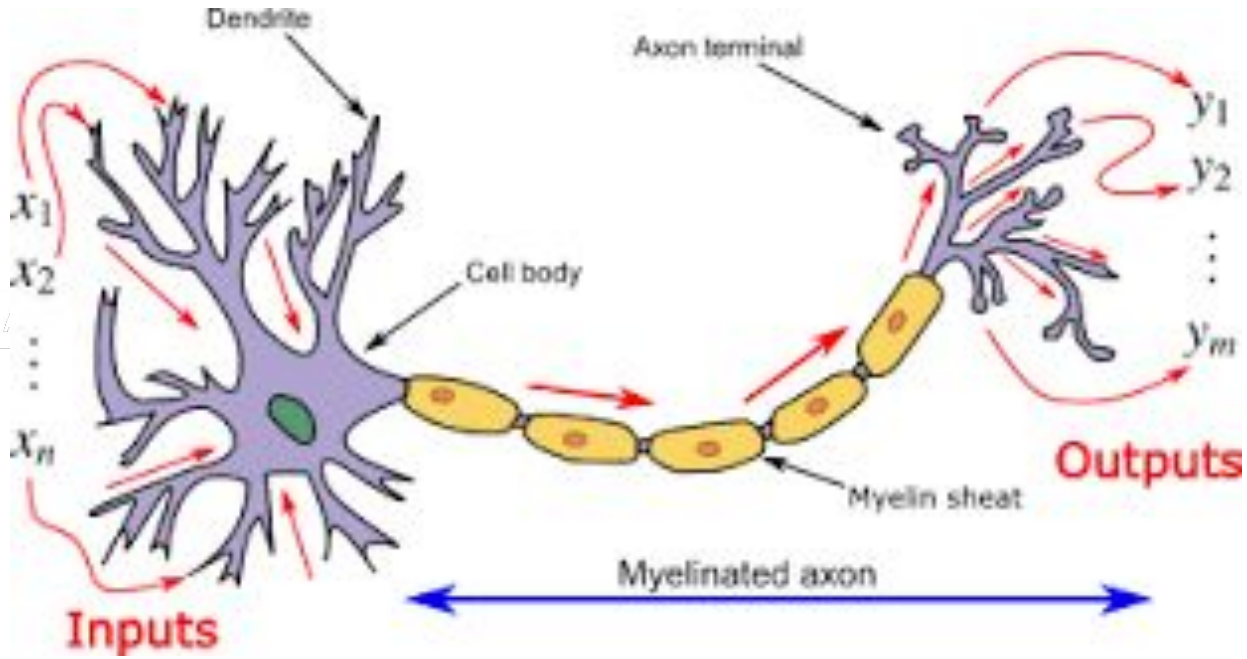


$$f = W_\gamma * max(0, W_\alpha * max(0, W_\beta * X))$$









Summary

Forward and Backward propagation in code

Strategies for abstracting and communicating network architecture (layers)

How computational graphs relate to neural networks

What “deep learning” actually means

How “deeper learning” can help when you have horses that face in different directions.

A bit on the biological inspiration of neural networks.