

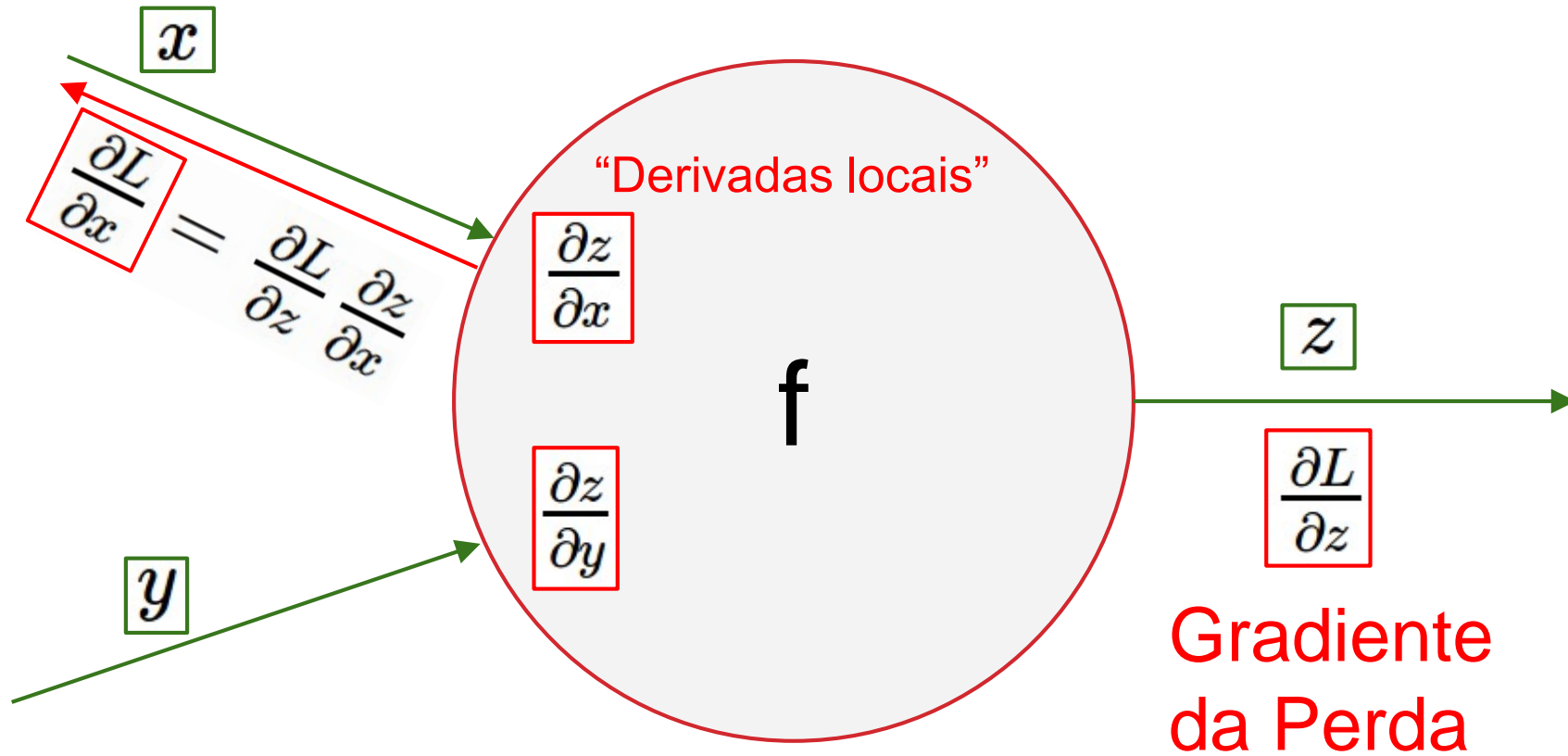
Redes Neurais e Aprendizagem Profunda

REDES NEURAIS ARTIFICIAIS

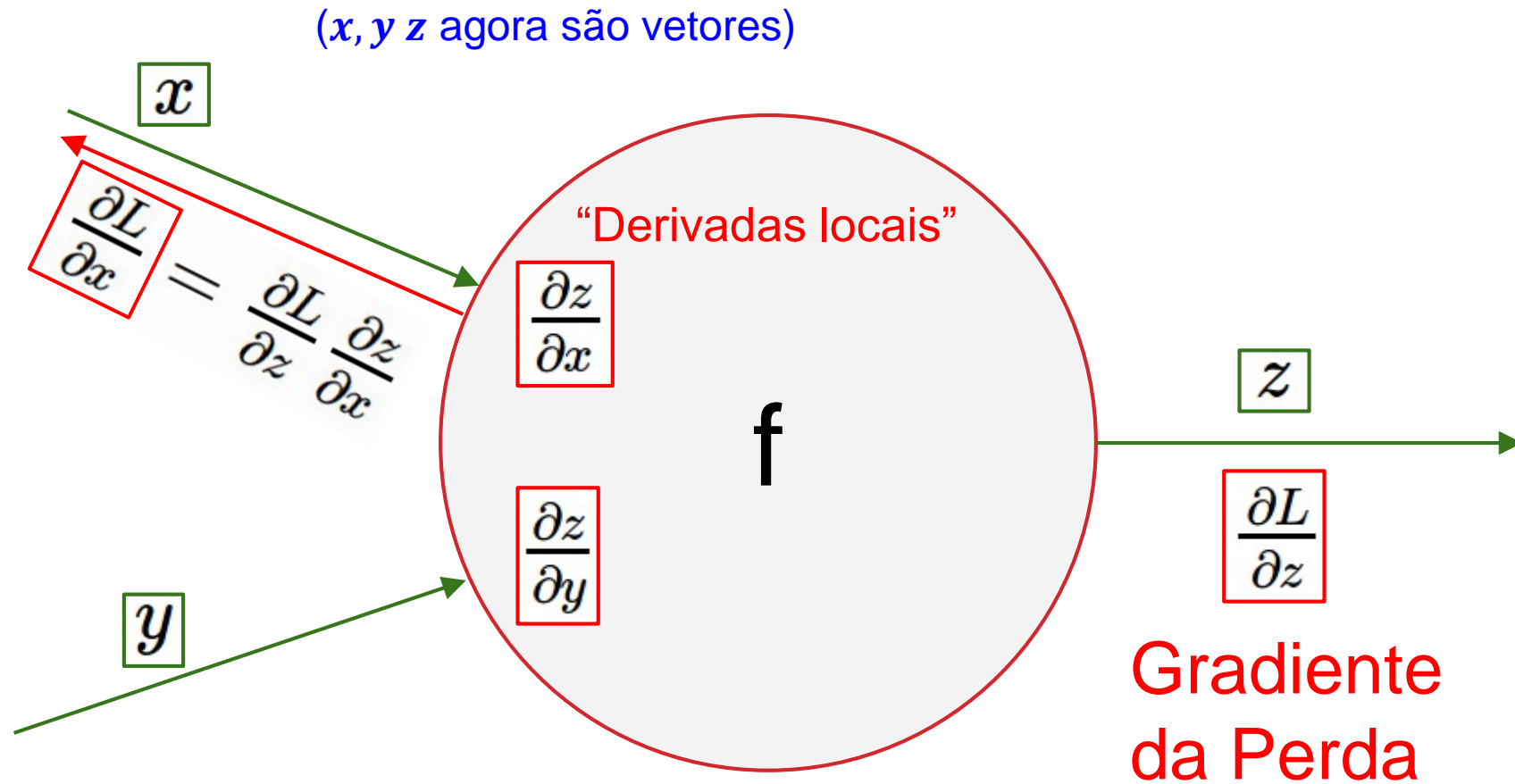
PROPAGAÇÃO RETRÓGRADA (III)

Zenilton K. G. Patrocínio Jr
zenilton@pucminas.br

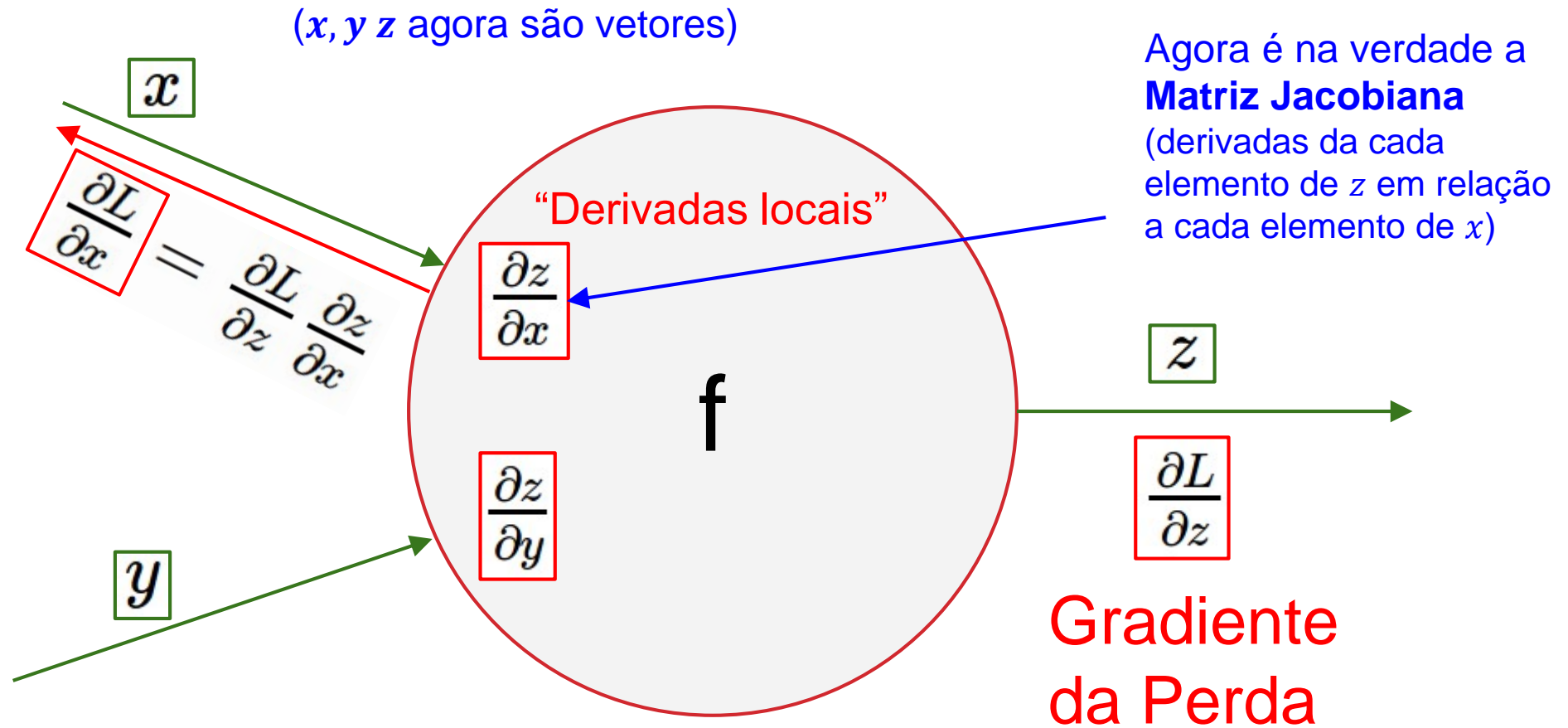
Gradientes para Dados Multidimensionais



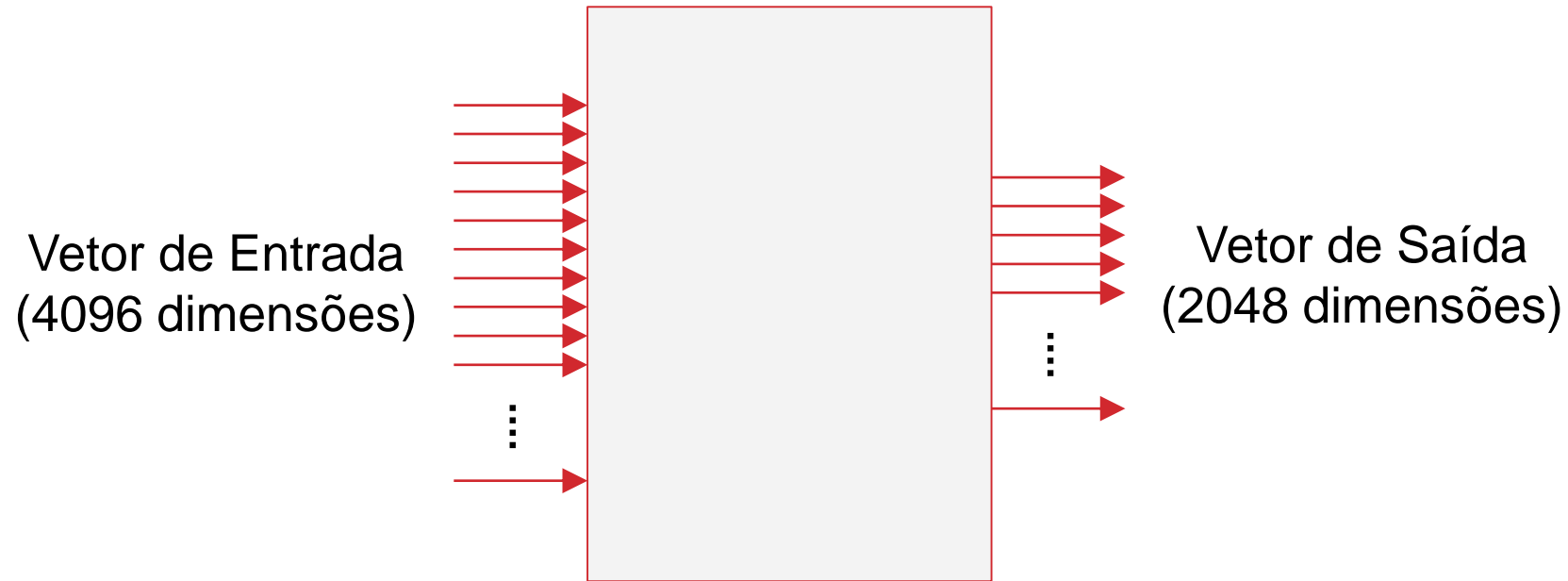
Gradientes para Dados Multidimensionais



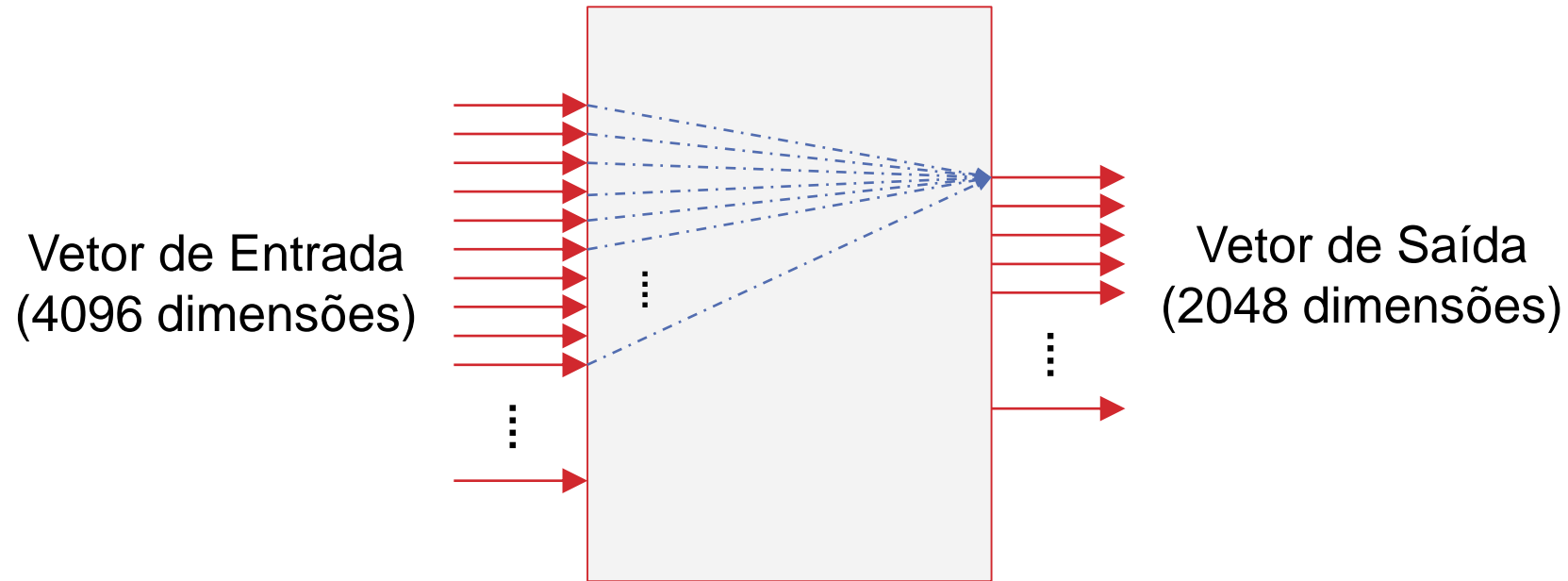
Gradientes para Dados Multidimensionais



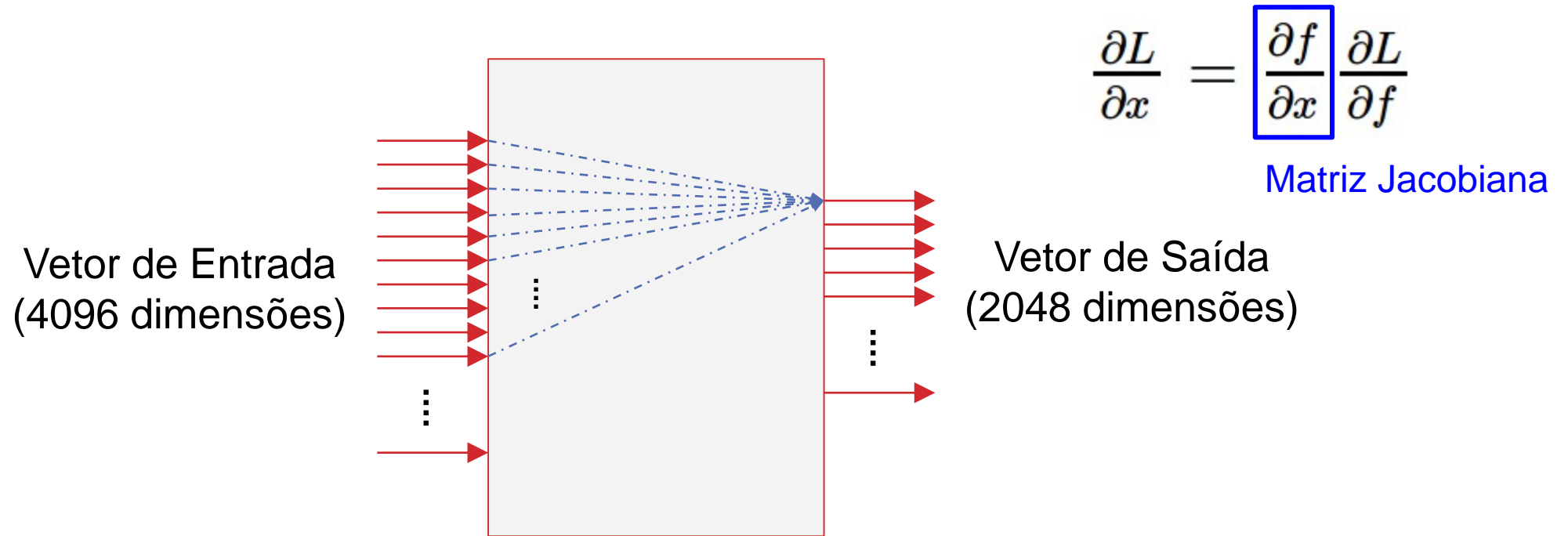
Gradientes para Dados Multidimensionais



Gradientes para Dados Multidimensionais



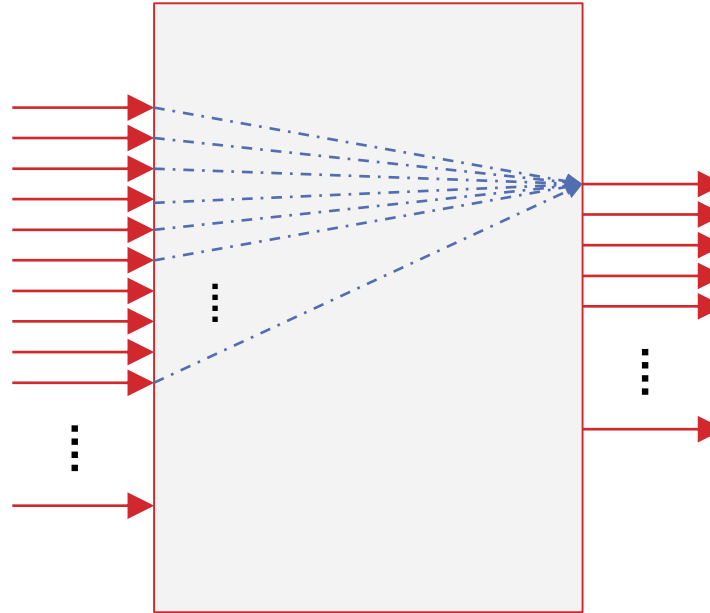
Gradientes para Dados Multidimensionais



Gradientes para Dados Multidimensionais

P1: qual o tamanho da matriz Jacobiana?

Vetor de Entrada
(4096 dimensões)



$$\frac{\partial L}{\partial x} = \boxed{\frac{\partial f}{\partial x}} \frac{\partial L}{\partial f}$$

Matriz Jacobiana

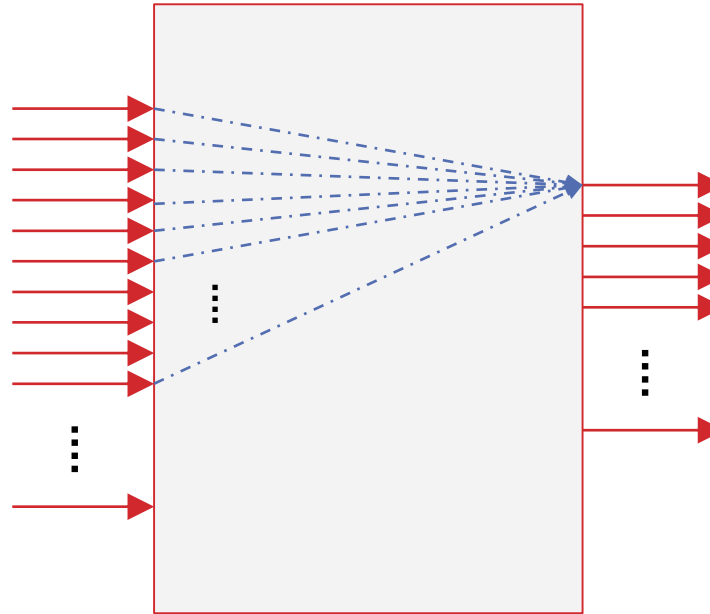
Vetor de Saída
(2048 dimensões)

Gradientes para Dados Multidimensionais

$$\frac{\partial L}{\partial x} = \boxed{\frac{\partial f}{\partial x}} \frac{\partial L}{\partial f}$$

Matriz Jacobiana

Vetor de Entrada
(4096 dimensões)



Vetor de Saída
(2048 dimensões)

P1: qual o tamanho
da matriz Jacobiana?

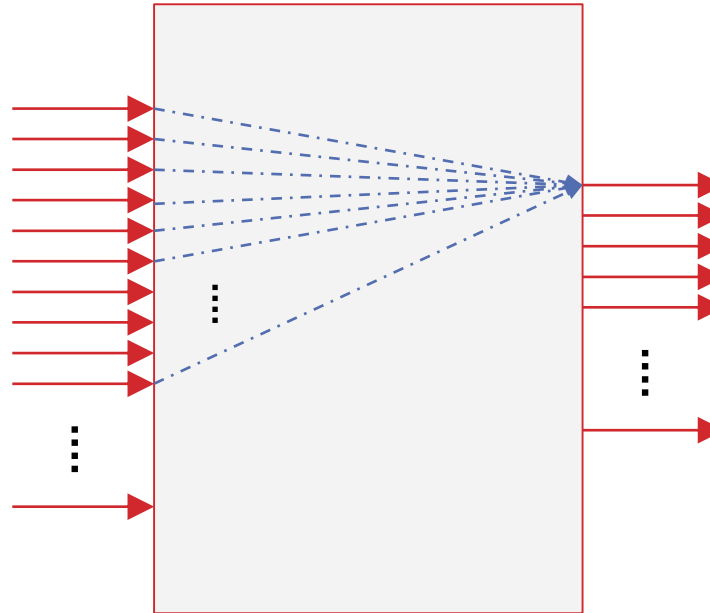
⇒ 2048 × 4096 !

Gradientes para Dados Multidimensionais

$$\frac{\partial L}{\partial x} = \boxed{\frac{\partial f}{\partial x}} \frac{\partial L}{\partial f}$$

Matriz Jacobiana

Vetor de Entrada
(4096 dimensões)



Vetor de Saída
(2048 dimensões)

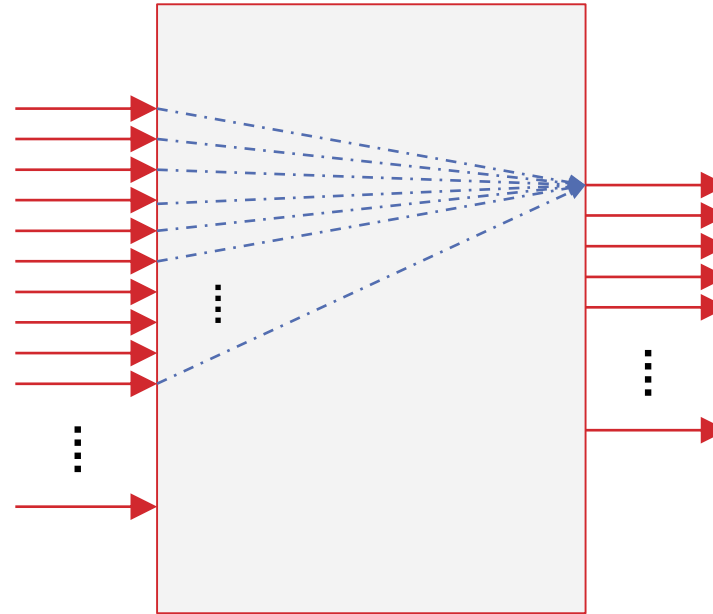
P1: qual o tamanho
da matriz Jacobiana?

⇒ 2048 × 4096 !

P2: qual a aparência
dessa matriz?

Gradientes para Dados Multidimensionais

Vetor de Entrada
(4096 dimensões)



P1: qual o tamanho
da matriz Jacobiana?

⇒ 2048 × 4096 !

$$\frac{\partial L}{\partial x} = \boxed{\frac{\partial f}{\partial x}} \frac{\partial L}{\partial f}$$

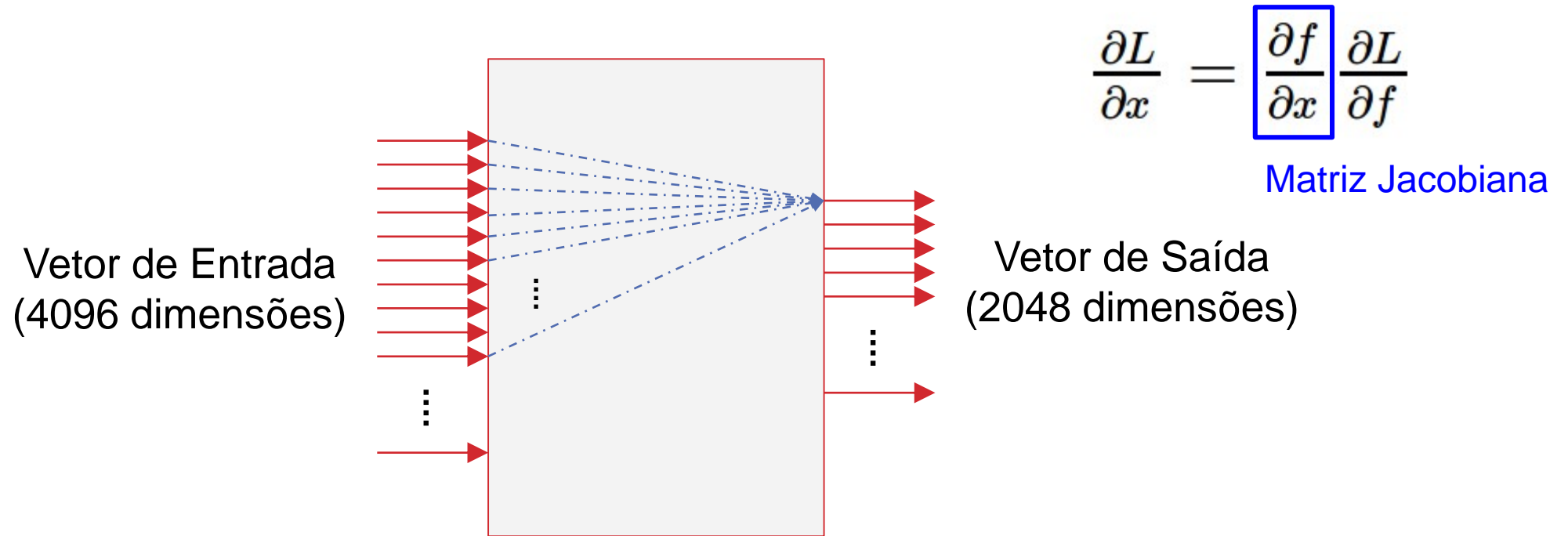
Matriz Jacobiana

Vetor de Saída
(2048 dimensões)

P2: qual a aparência
dessa matriz?

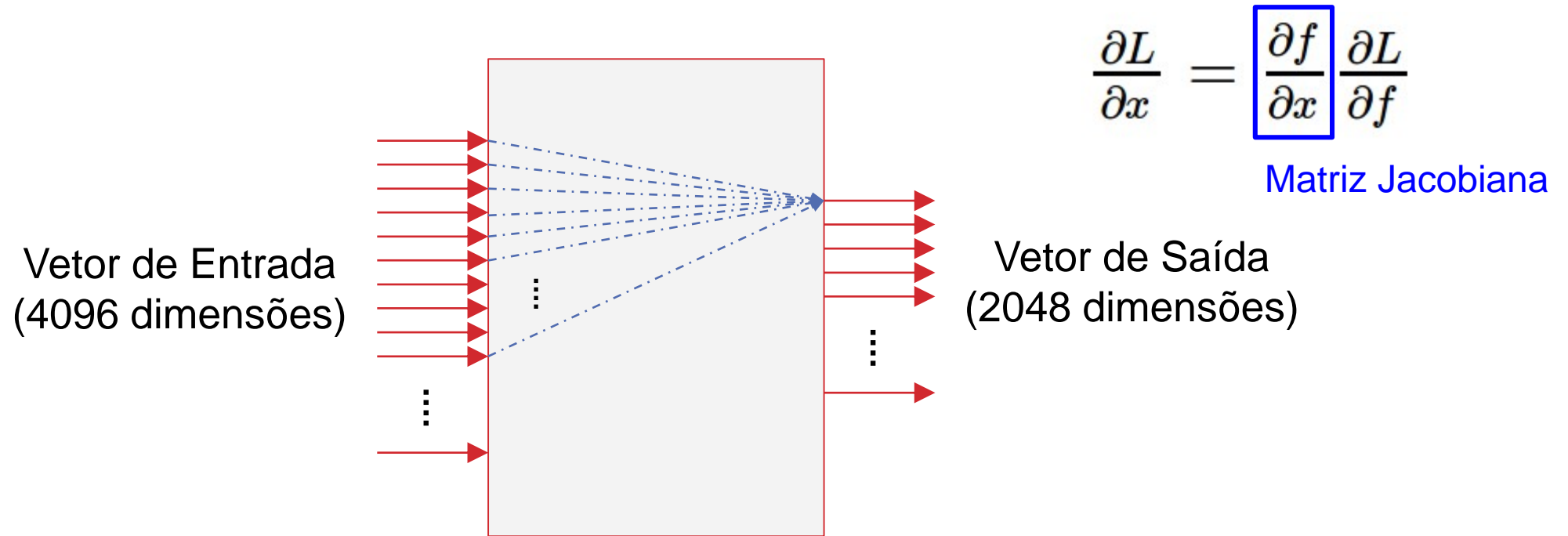
$$\begin{bmatrix} \frac{\partial f_1}{\partial x_1} & \frac{\partial f_1}{\partial x_2} & \dots & \frac{\partial f_1}{\partial x_m} \\ \frac{\partial f_2}{\partial x_1} & \frac{\partial f_2}{\partial x_2} & \dots & \frac{\partial f_2}{\partial x_m} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_k}{\partial x_1} & \frac{\partial f_k}{\partial x_2} & \dots & \frac{\partial f_k}{\partial x_m} \end{bmatrix}$$

Gradientes para Dados Multidimensionais



Na prática, processa-se
todo um lote ou “*minibatch*”
(p.ex. 100 amostras) de
uma só vez

Gradientes para Dados Multidimensionais



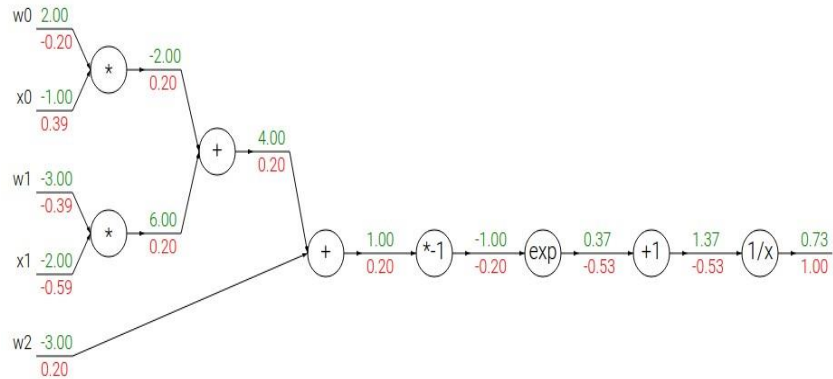
Na prática, processa-se todo um lote ou “*minibatch*” (p.ex. 100 amostras) de uma só vez

Assim, as dimensões da matriz Jacobiana desse exemplo seriam

$$204.800 \times 409.600$$

≈ 83,9 bilhões de pesos :(

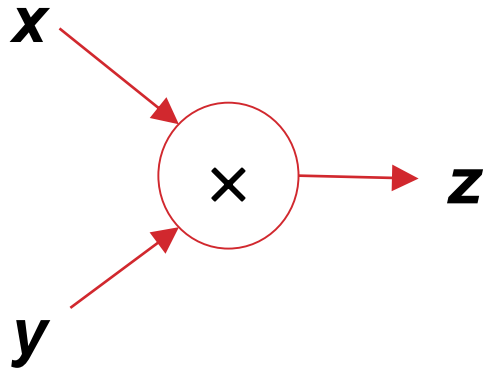
Implementação – Forward / Backward API



Para um grafo ou rede (*pseudocódigo*)

```
class ComputationalGraph(object):  
    #...  
    def forward(inputs):  
        # 1. [pass inputs to input gates...]  
        # 2. forward the computational graph:  
        for gate in self.graph.nodes_topologically_sorted():  
            gate.forward()  
        return loss # the final gate in the graph outputs the loss  
    def backward():  
        for gate in reversed(self.graph.nodes_topologically_sorted()):  
            gate.backward() # little piece of backprop (chain rule applied)  
        return inputs_gradients
```

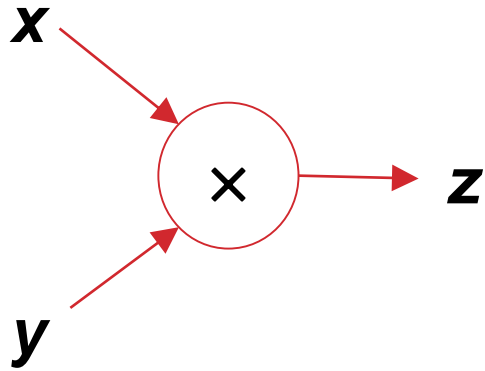
Implementação – Forward / Backward API



(x, y, z escalares)

```
class MultiplyGate(object):  
    def forward(x,y):  
        z = x*y  
        return z  
    def backward(dz):  
        # dx = ... #todo  
        # dy = ... #todo  
        return [dx, dy]
```

Implementação – Forward / Backward API

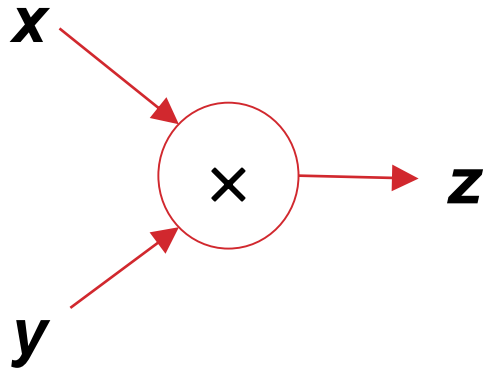


(x , y , z escalares)

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Implementação – Forward / Backward API



(x, y, z escalares)

```
class MultiplyGate(object):
```

```
    def forward(x,y):
```

```
        z = x*y
```

```
        return z
```

```
    def backward(dz):
```

```
        # dx = ... #todo
```

```
        # dy = ... #todo
```

```
        return [dx, dy]
```

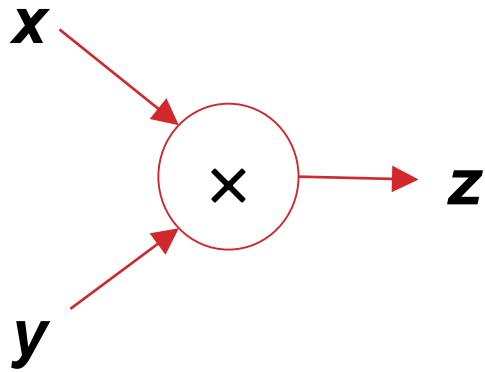
$$\frac{\partial L}{\partial z}$$

An arrow points from this box to the `dz` parameter in the `backward` method definition.

$$\frac{\partial L}{\partial x}$$

An arrow points from this box to the `dx` element in the `return` statement of the `backward` method.

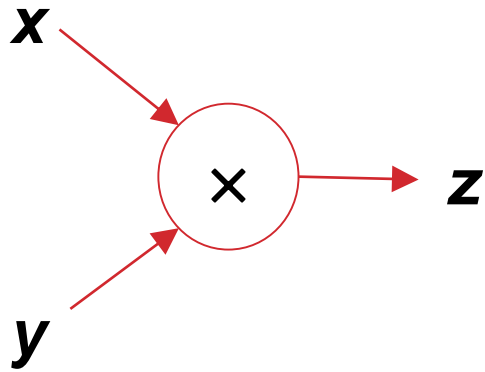
Implementação – Forward / Backward API



(x, y, z escalares)

```
class MultiplyGate(object):  
    def forward(x,y):  
        z = x*y  
        self.x = x # must keep these around!  
        self.y = y  
        return z  
    def backward(dz):  
        dx = self.y * dz # [dz/dx * dL/dz]  
        dy = self.x * dz # [dz/dy * dL/dz]  
        return [dx, dy]
```

Implementação – Forward / Backward API



(x , y , z escalares)

```
class MultiplyGate(object):  
    def forward(x,y):  
        z = x*y  
        self.x = x # must keep these around!  
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        dx = self.y * dz # [dz/dx * dL/dz]  
        dy = self.x * dz # [dz/dy * dL/dz]  
        return [dx, dy]
```



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No description or website provided.															
1,839 commits		377 branches		79 releases		88 contributors									
Search master		View pull requests		New file		Find file		HTTPS		https://github.com/torch/nn		Download ZIP			
nnvectors Merge pull request #955 from torchresearch/nnvectors												Latest commit 2385176 15 hours ago			
nnvectors		Fix batch mode in MergeRankingCriterion							4 days ago						
nnvectors		Improve error message in SpatialConvolutionMM							4 days ago						
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nnvectors		Adding in-place AddConstant and MulConstant							5 months ago						
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nnvectors		fix batchnorm reset							3 months ago						
nnvectors		fixing table modules to return correct number of gradients							6 months ago						
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nnvectors		Use tensor for THNN functions even for single element outputs							10 days ago						
nnvectors		Add batch mode in SoftProduct + unit test							2 months ago						
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nnvectors		reorder HingeEmbeddingCriterion to support batch mode							6 months ago						
nnvectors		Revert to previous Identity.lua implementation							2 months ago						
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LogSigmoid.lua	Add THNN conversion of (B,1,1,LeakyReLU,LogSigmoid,LogSoftMax,Looku...	7 days ago
LogSoftMax.lua	Add THNN conversion of (B,1,1,LeakyReLU,LogSigmoid,LogSoftMax,Looku...	7 days ago
LookupTable.lua	Harmonize LookupTable signature with torch.nn	5 days ago
MM.lua	Rename unpack to table.unpack for Lua 5.2	6 months ago
MSECriterion.lua	Add ScaleAverage to criterion in the constructor	2 months ago
MergeCriterion.lua	modernized MergeCriterion	4 years ago
MergeRankingCriterion.lua	Fix batch mode in MergeRankingCriterion	4 days ago
Misc.lua	Merge pull request #884 from vighnesh	2 months ago
Misc.lua	Add support for negative dimension and both batch and non batch input...	2 months ago
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MiscTable.lua	cannot unrolled variable and useless expression	26 days ago
Module.lua	Reset "Can't re-define parameters if they are already defined"	15 hours ago
Mul.lua	removing the requirement for providing ops in nn.Module	4 years ago
MulConstant.lua	Ignore updateOutInput if self.gradInput is nil	3 months ago
MulCriterion.lua	asserts in MulCriterion and ParallelCriterion add	2 months ago
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MulTableMergeCriterion.lua	multiversion supports grad	11 months ago
Narrow.lua	typo in Narrow not done in place	6 months ago
NarrowTable.lua	NarrowTable	6 months ago
Norm.lua	Remove inner and backward from NormTables, because they allocate memory ...	21 days ago
NormTable.lua	Buffer for PReLU code implementation	6 months ago
Padding.lua	fixed bug in Padding: input was returned in backward	5 months ago
ParallelCriterion.lua	Merge pull request #852 from vighnesh	28 days ago
Parallel.lua	fix a bug in conditional expression	4 months ago
ParallelCriterion.lua	asserts in MulCriterion and ParallelCriterion add	2 months ago
ParallelTable.lua	Parallel optimization: ParallelTable inherits Container: unit tests	4 years ago
Power.lua	Use UNO line endings	7 months ago
ReLU.lua	docs: mathnotation	5 months ago
ReLU.lua	Add randomized leaky modified linear unit (ReLU)	3 months ago
ReLU.lua	adds in-place ReLU and fixes a potential divide-by-zero in nn.Soft	6 months ago
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Code Issues Pull requests Wiki Pulse Graphs Watch 10 Fork 10	
No description or website provided.	
1,139 commits 37 branches 10 releases 10 contributors	
Search master + New pull request	New file Find file HTTPS - https://github.com/torch/nn Download ZIP
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[illegible]