# Self-Attention

Shusen Wang

# Self-Attention

- Self-Attention: attention beyond Seq2Seq models.
- The original self-attention paper uses LSTM.
- To make teaching easy, I replace LSTM by SimpleRNN.

**Original paper:**

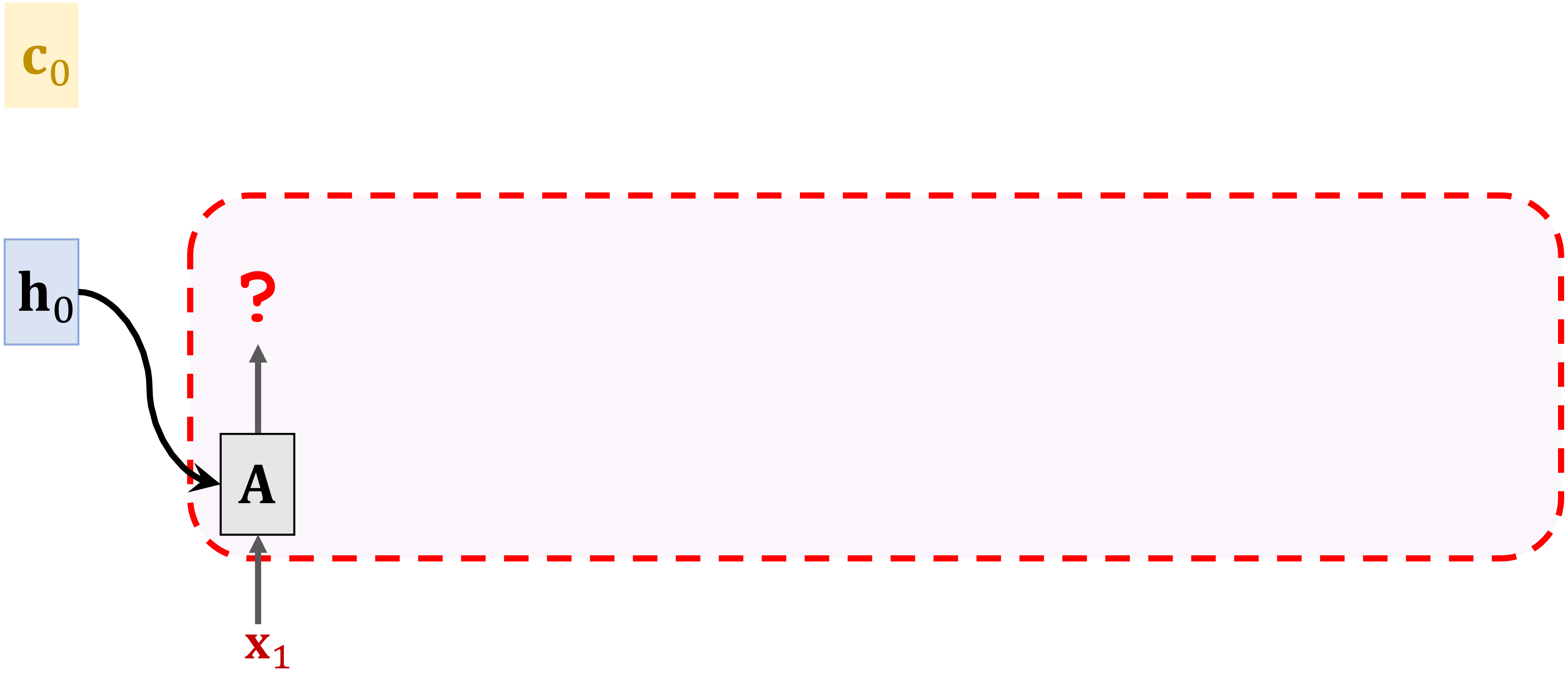
- Cheng, Dong, & Lapata. Long Short-Term Memory-Networks for Machine Reading. In *EMNLP*, 2016.

# SimpleRNN + Self-Attention

$\mathbf{c}_0 = \mathbf{0}$

$\mathbf{h}_0 = \mathbf{0}$

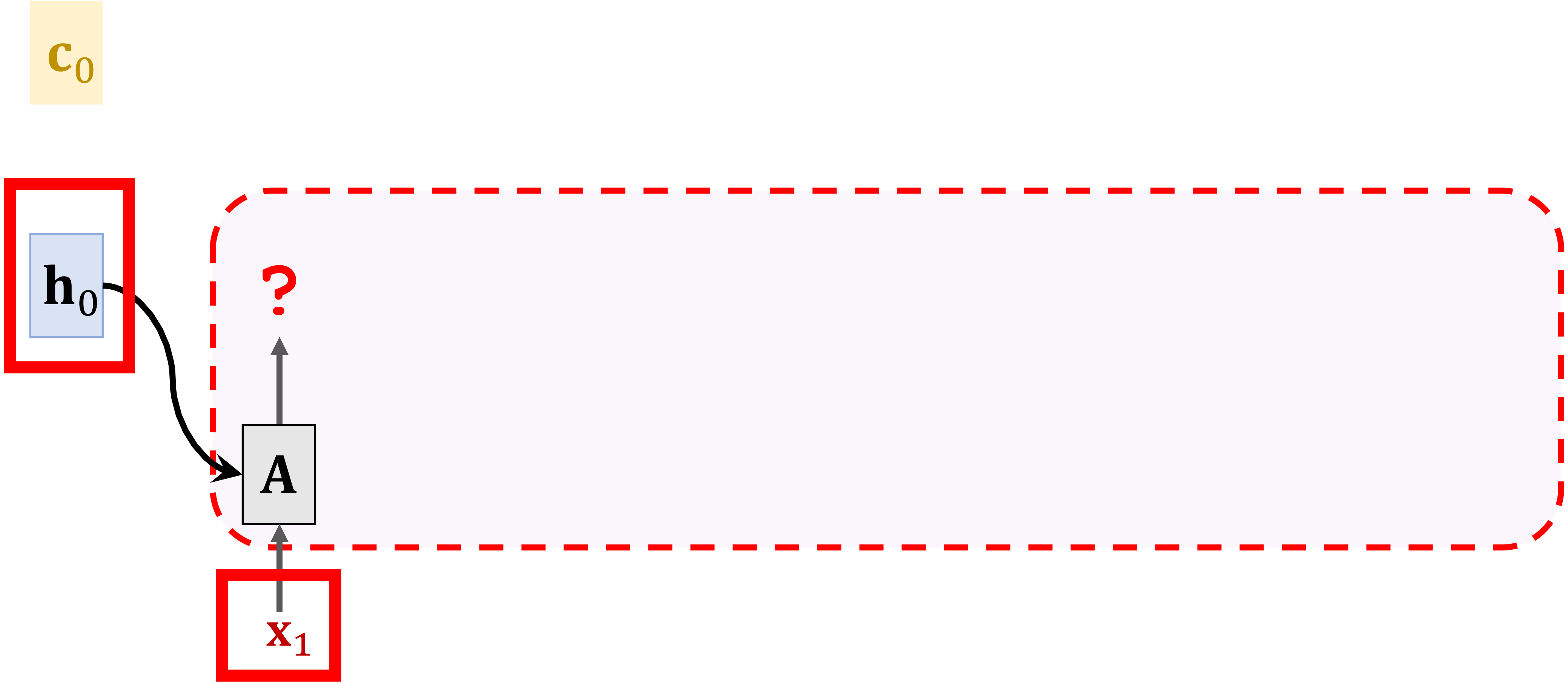
# SimpleRNN + Self-Attention



# SimpleRNN + Self-Attention

**SimpleRNN:**

$$\mathbf{h}_1 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{h}_0 \end{bmatrix} + \mathbf{b}\right)$$



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SimpleRNN:

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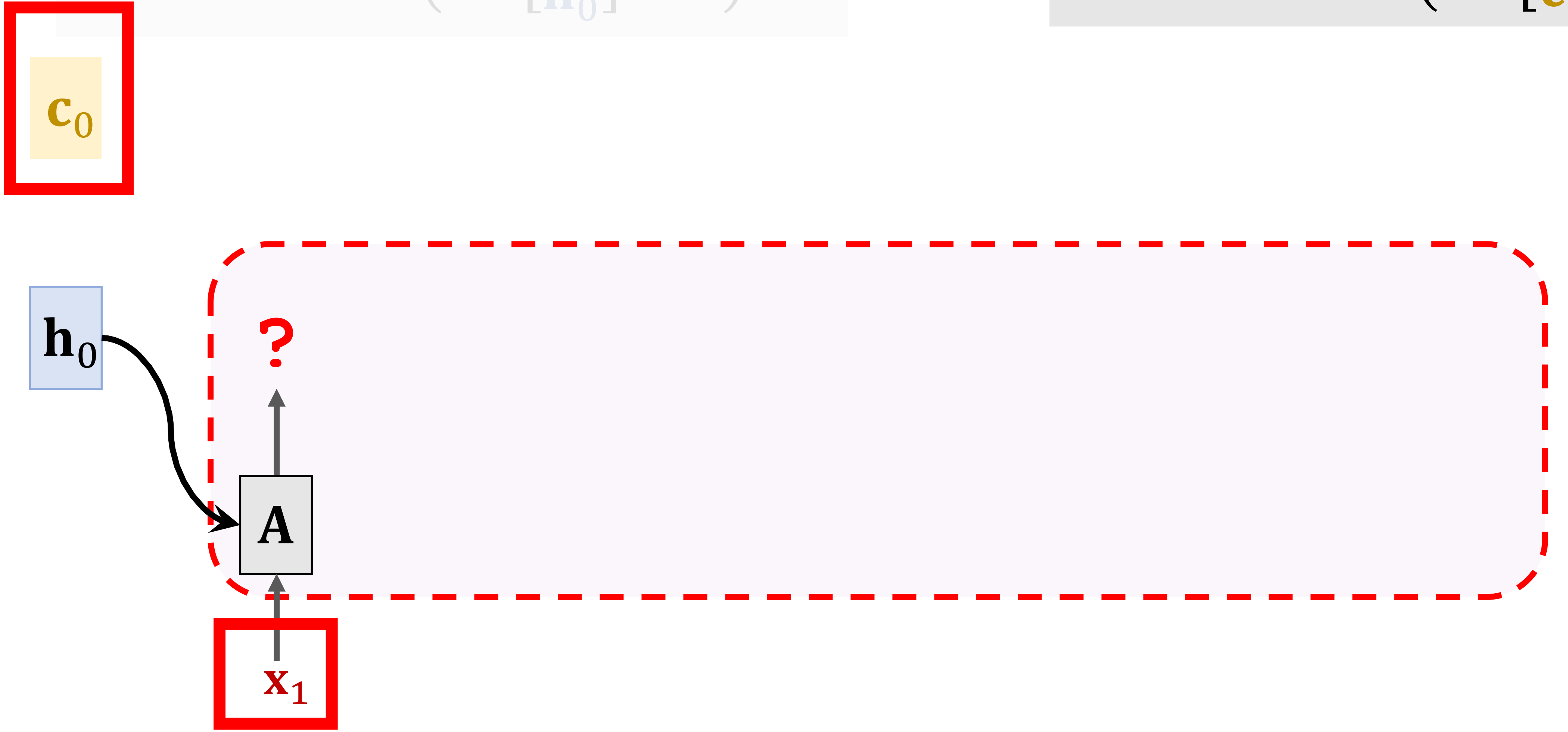
SimpleRNN + Self-Attention:

$$\mathbf{h}_1 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{c}_0 \end{bmatrix} + \mathbf{b}\right)$$



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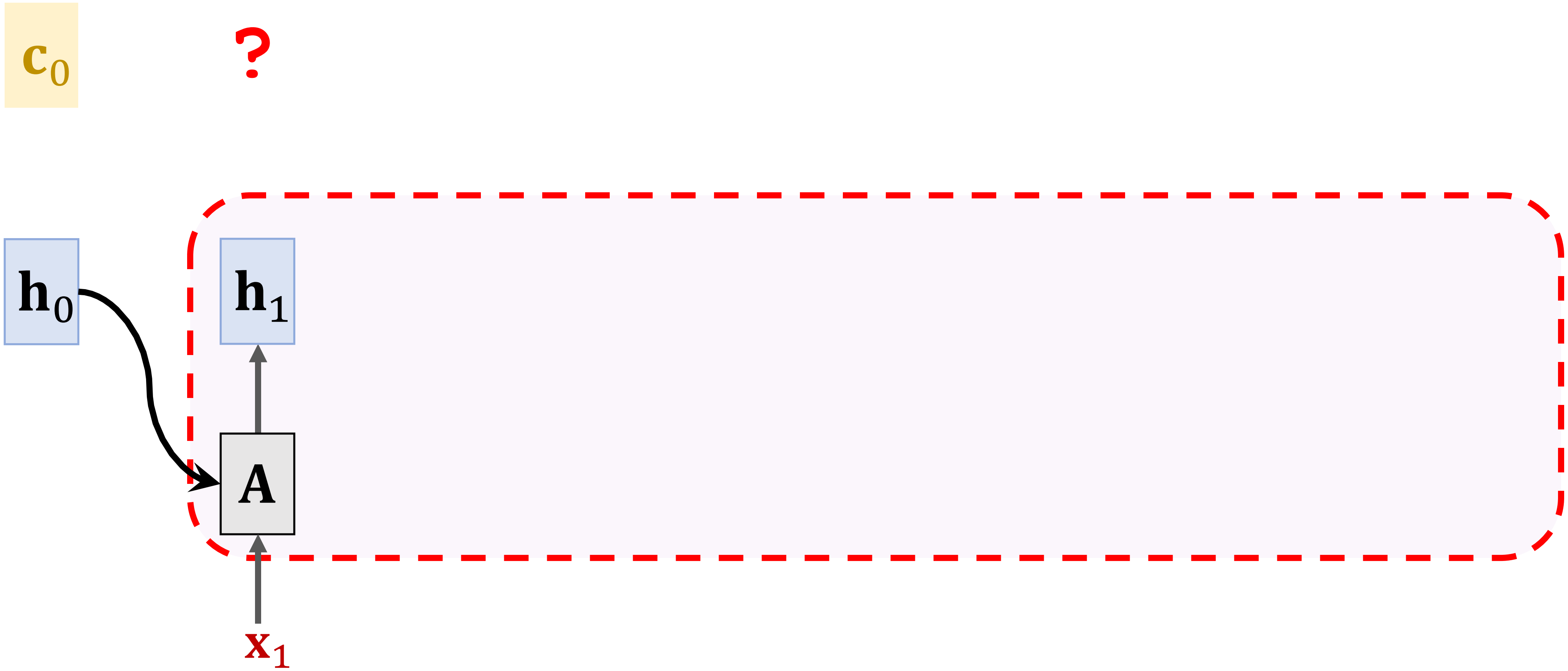
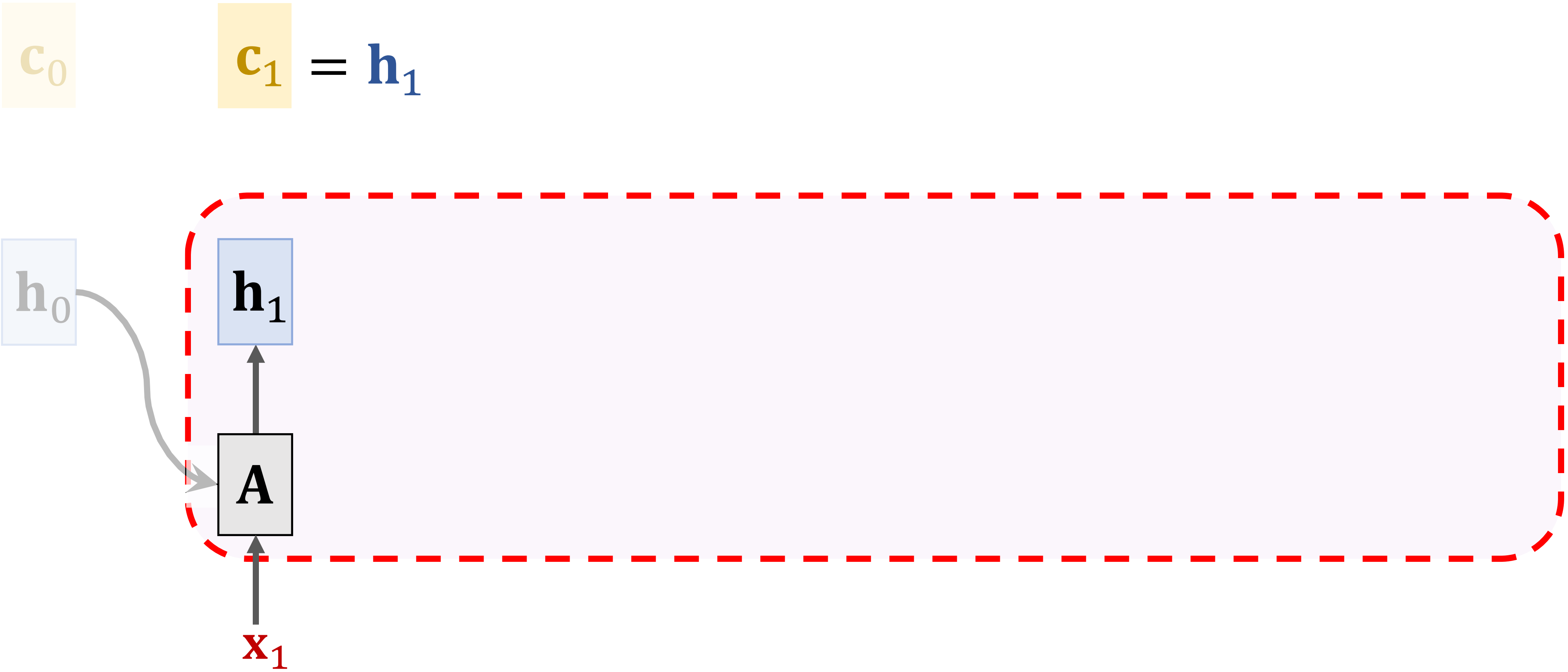


# SimpleRNN + Self-Attention

First context vector: $\mathbf{c}_1 = \mathbf{h}_1$.



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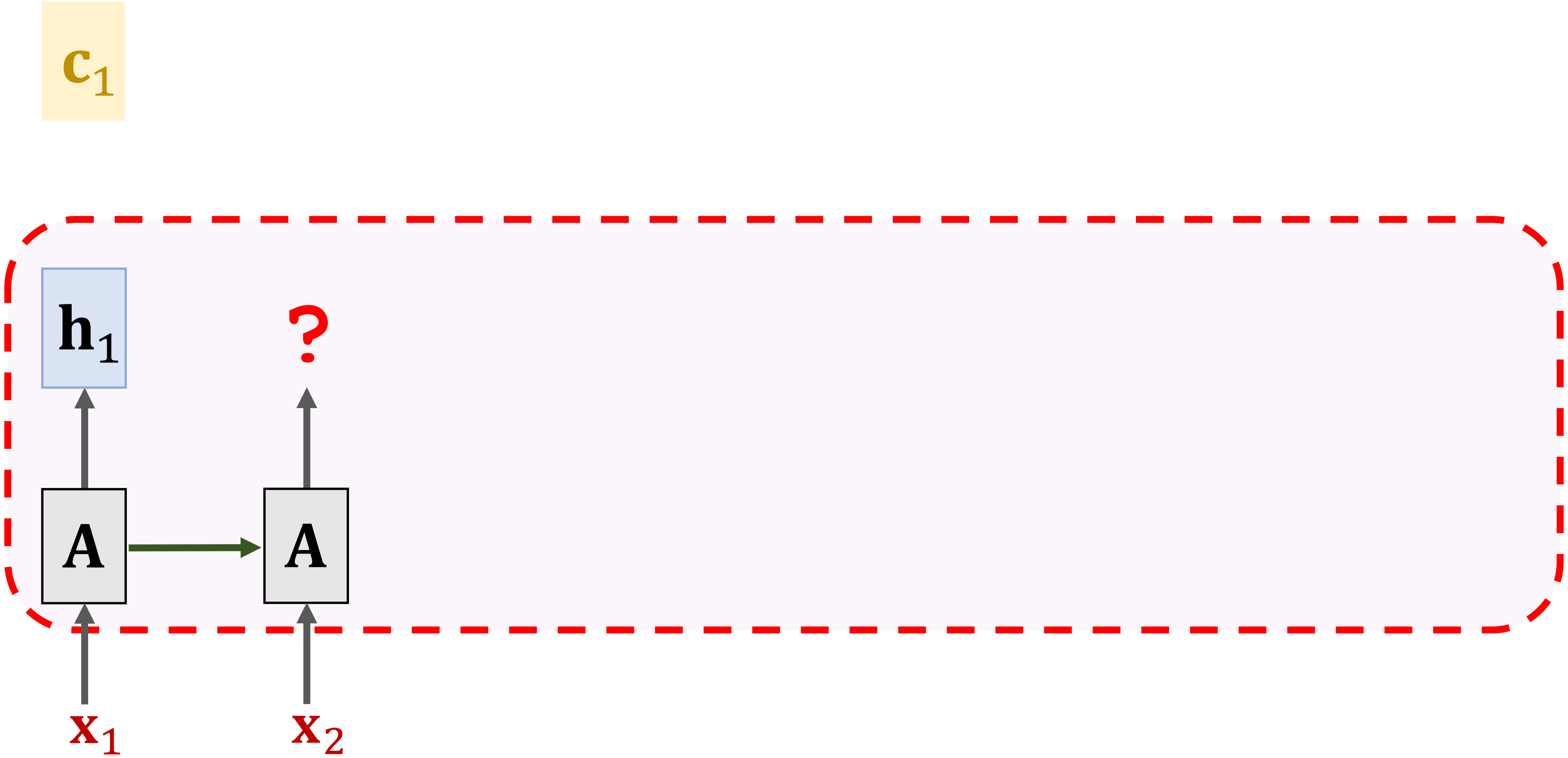

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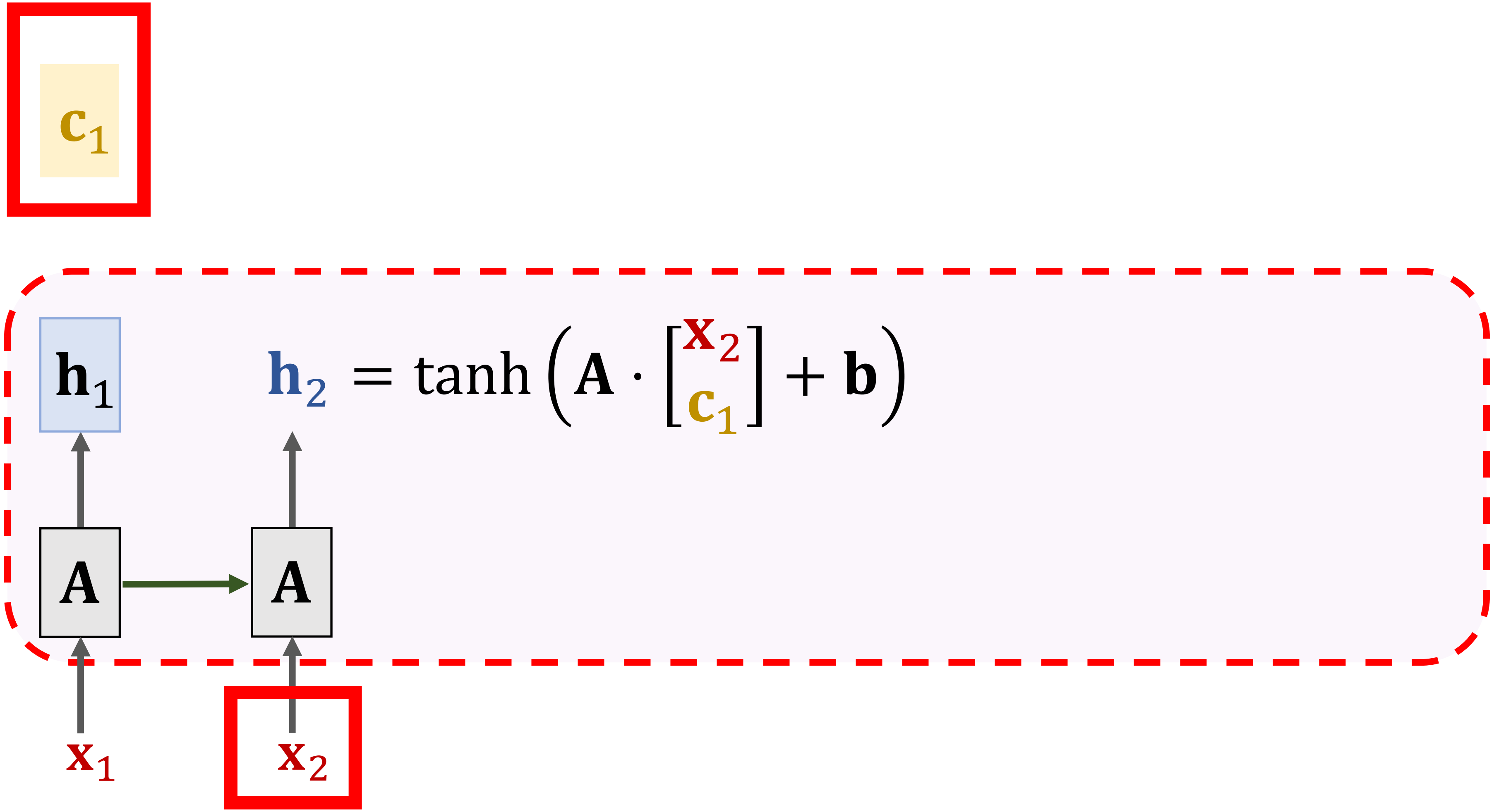
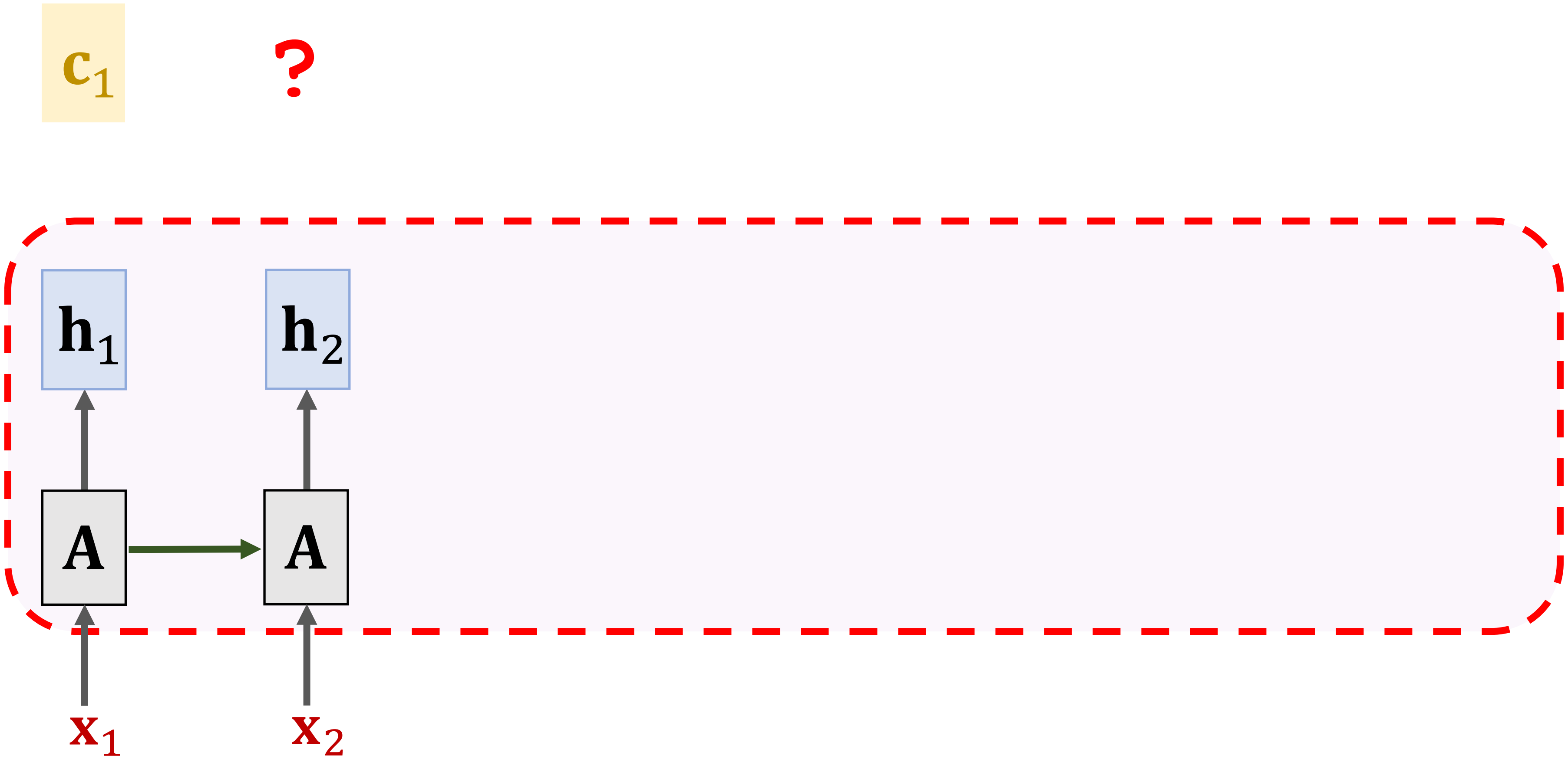


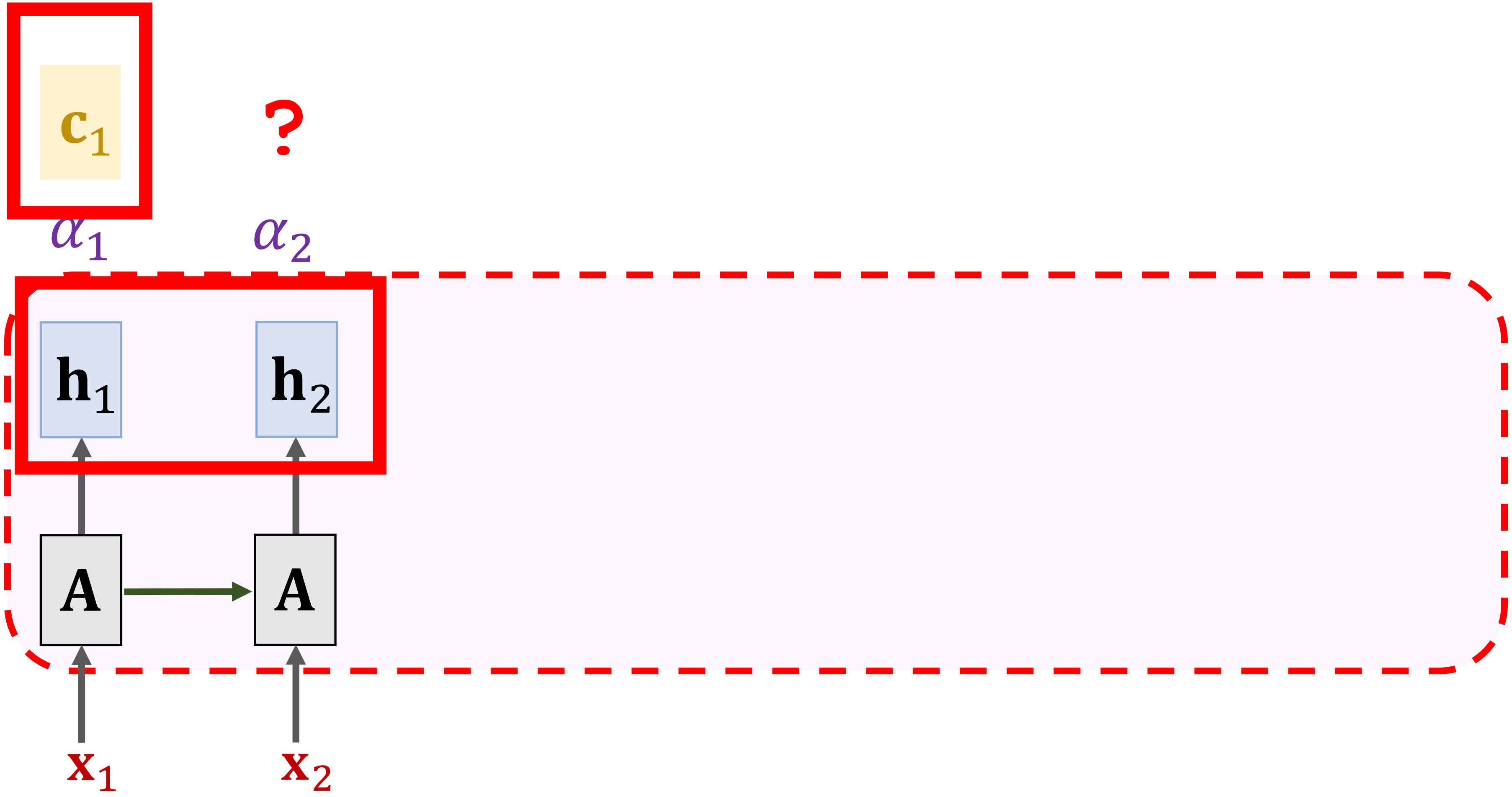
$$\mathbf{h}_2 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_2 \\ \mathbf{c}_1 \end{bmatrix} + \mathbf{b}\right)$$

# SimpleRNN + Self-Attention



# SimpleRNN + Self-Attention

**Weights:** $\alpha_i = \text{similarity}(\mathbf{h}_i,\ \mathbf{c}_1)$



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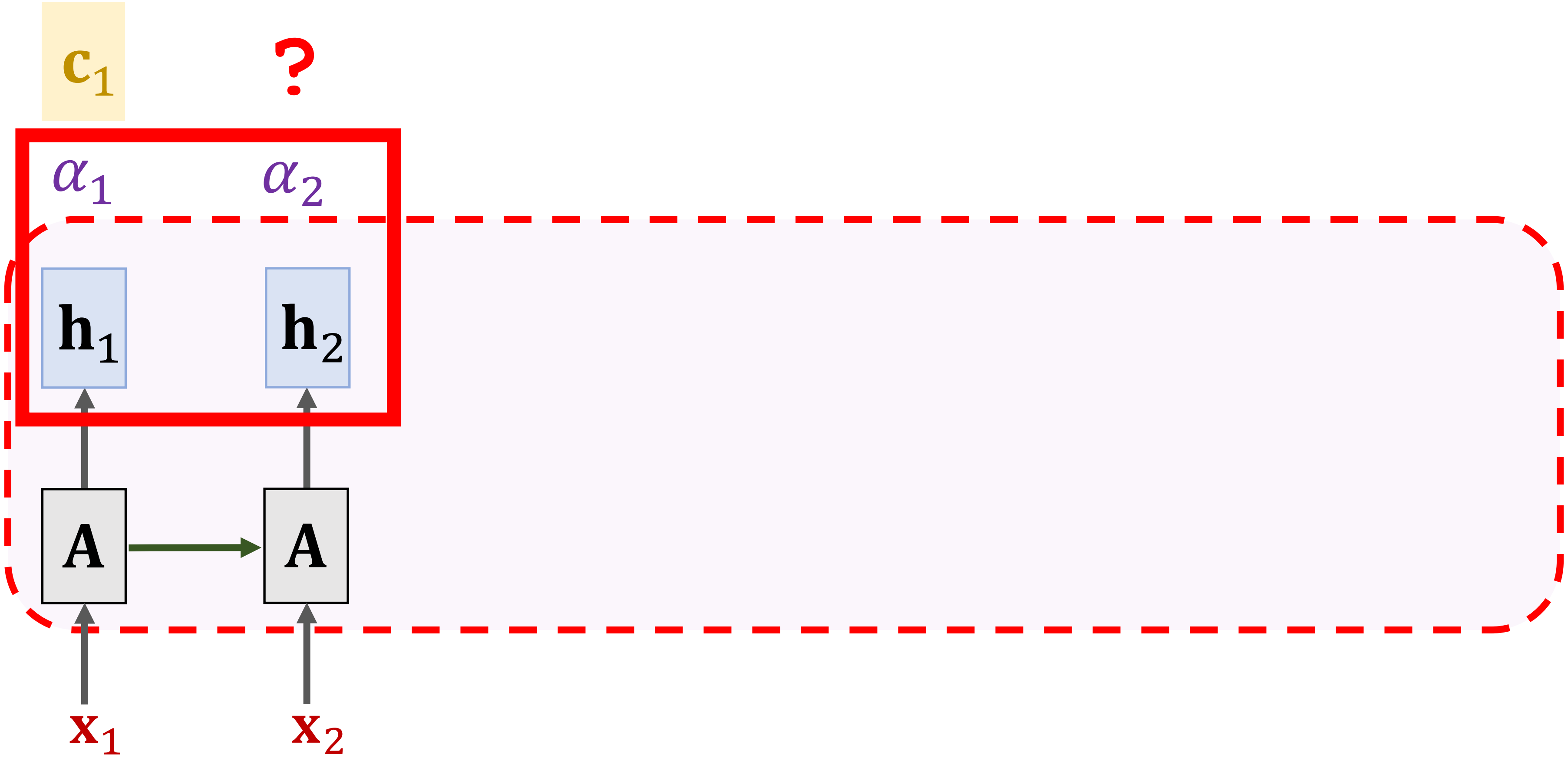

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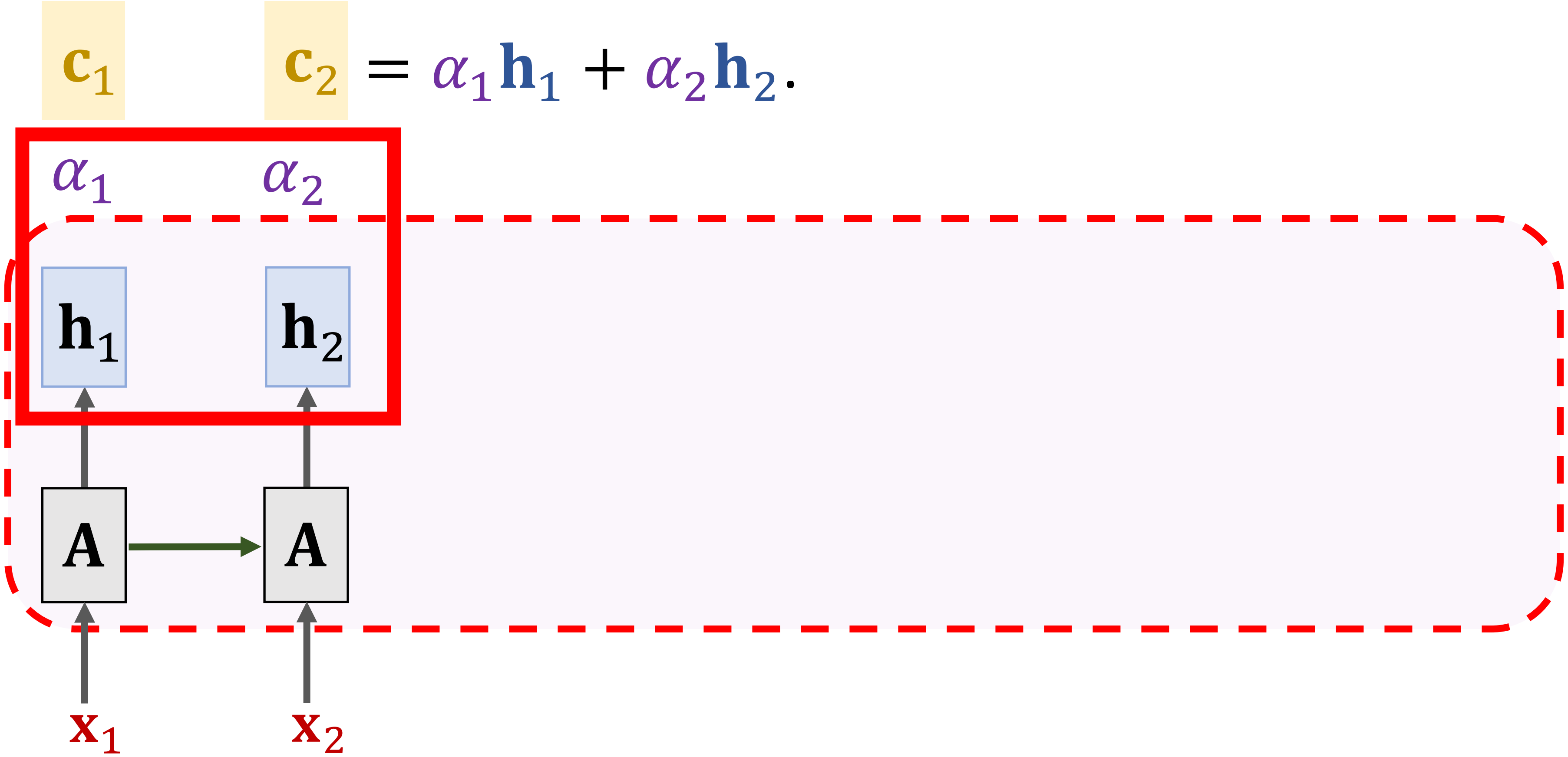
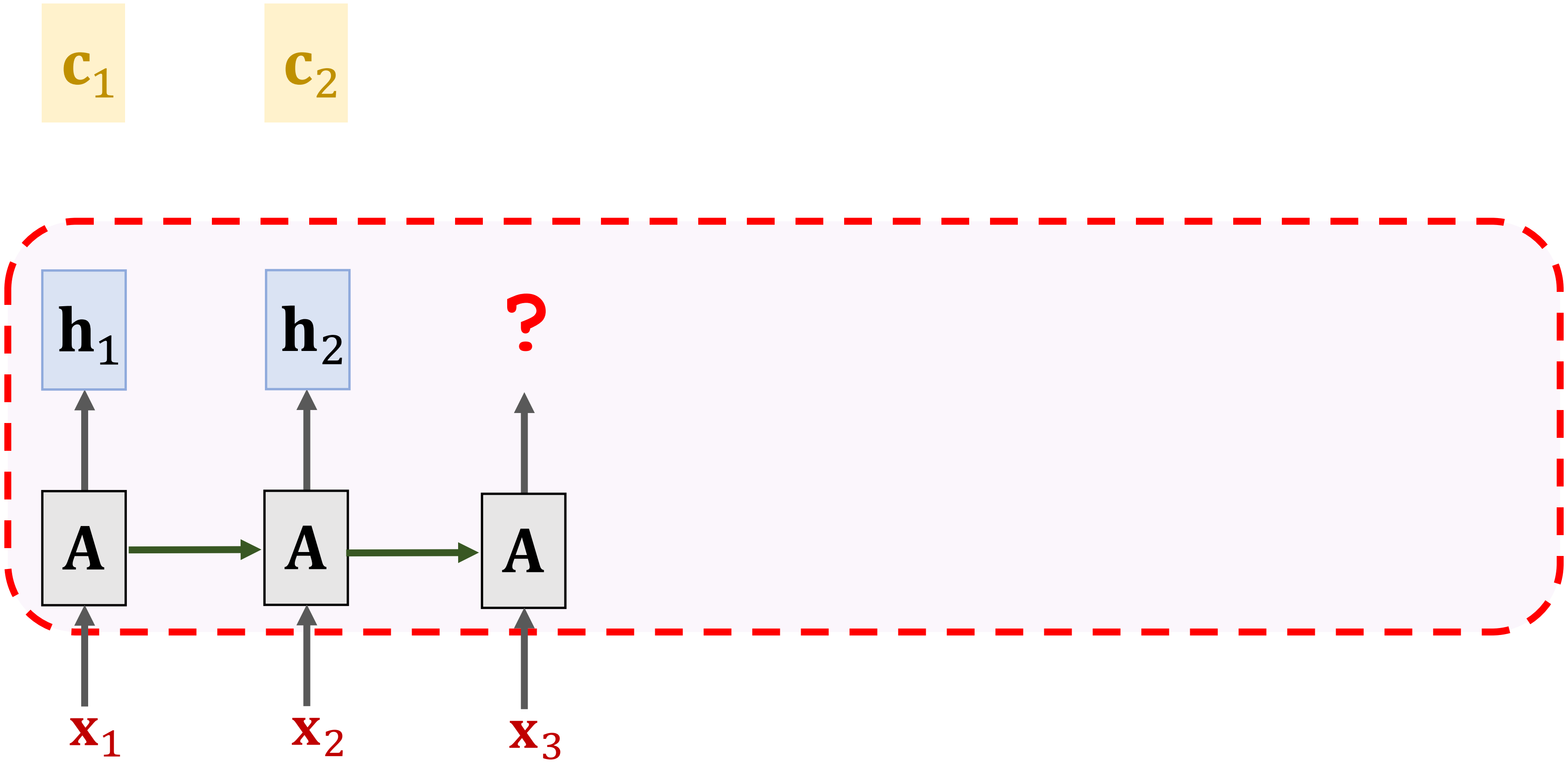


$\mathbf{c}_2 = \alpha_1 \mathbf{h}_1 + \alpha_2 \mathbf{h}_2.$

# SimpleRNN + Self-Attention



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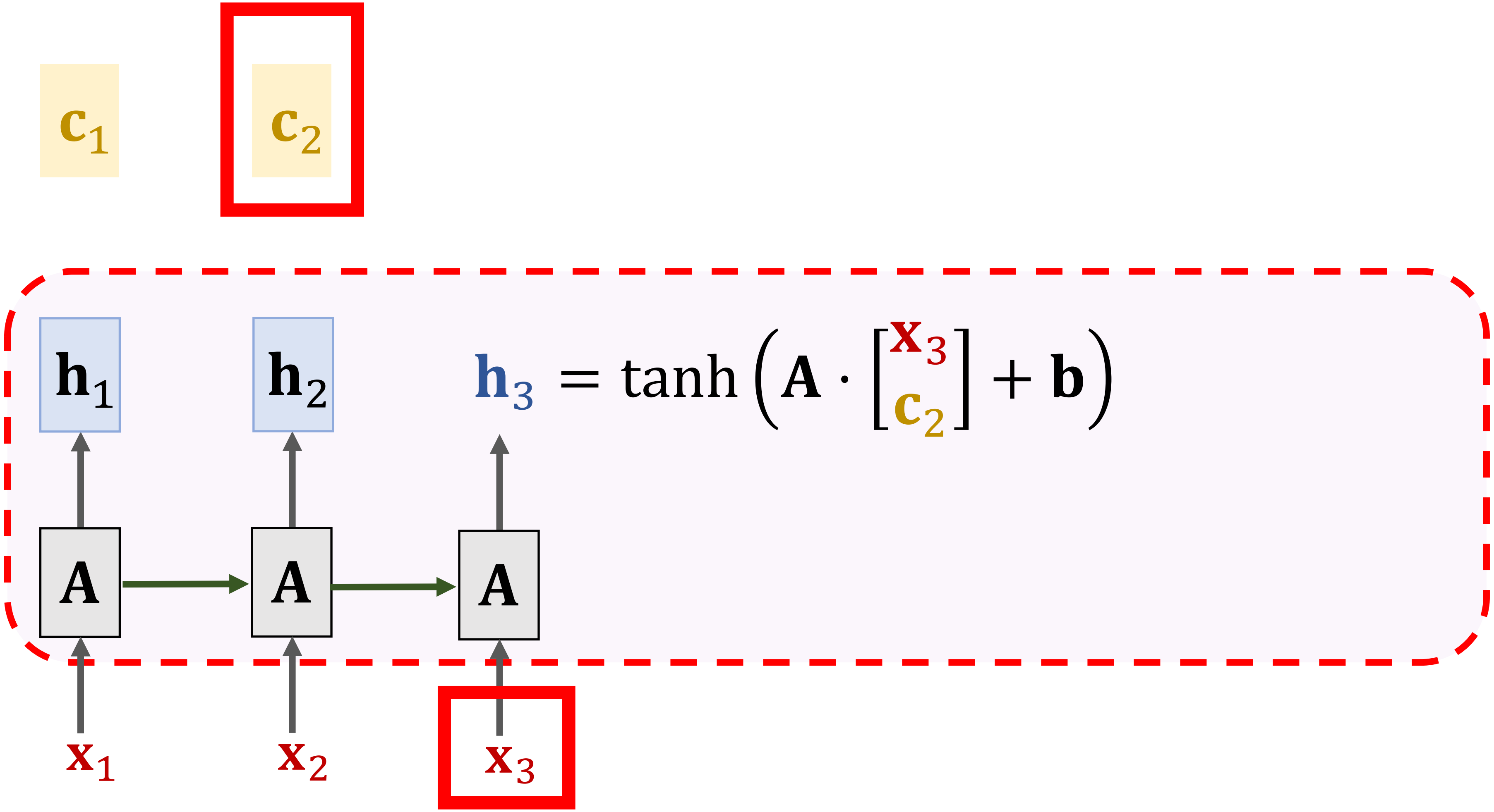
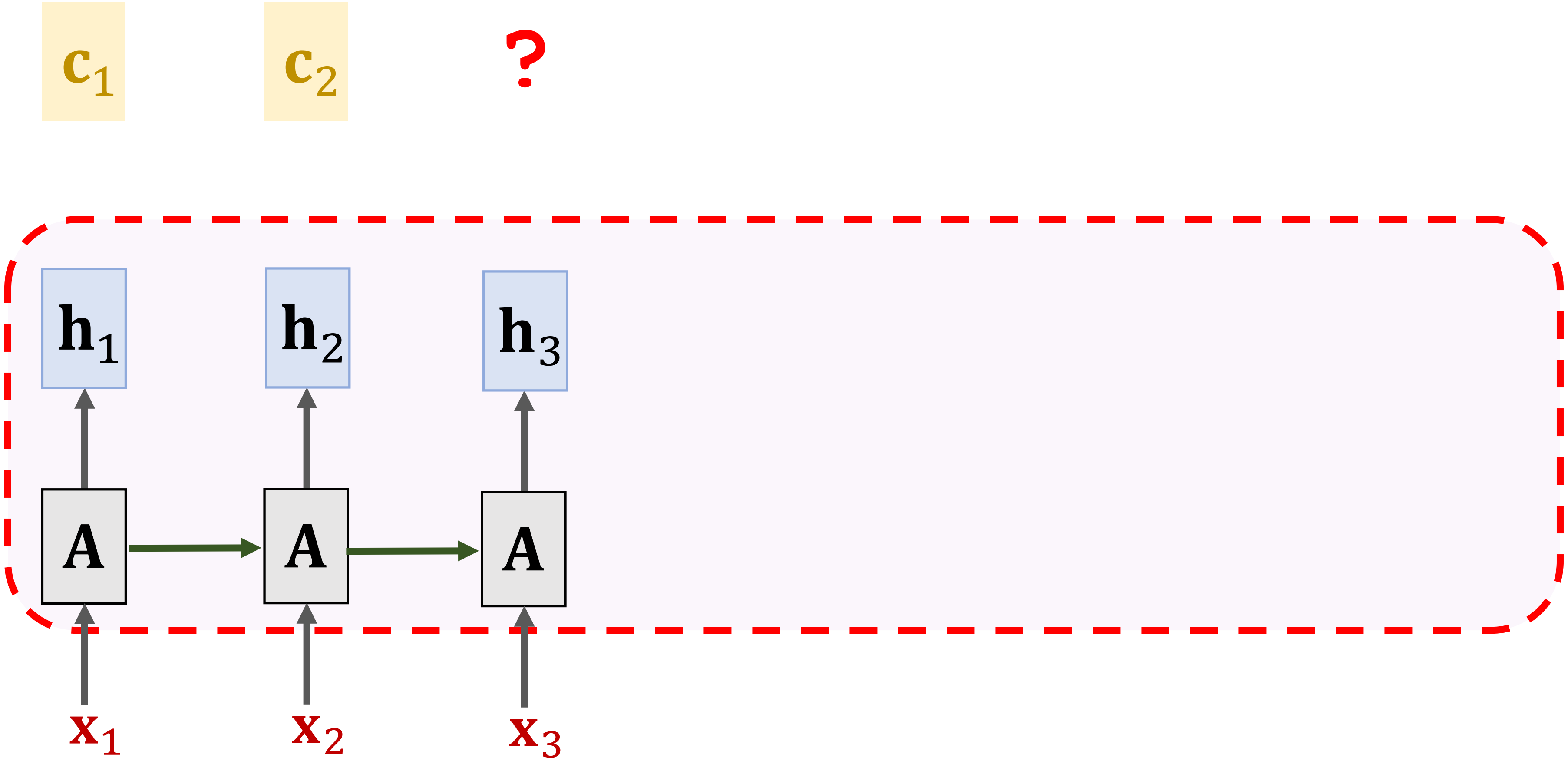


$$\mathbf{h}_3 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_3 \\ \mathbf{c}_2 \end{bmatrix} + \mathbf{b}\right)$$

# SimpleRNN + Self-Attention



# SimpleRNN + Self-Attention

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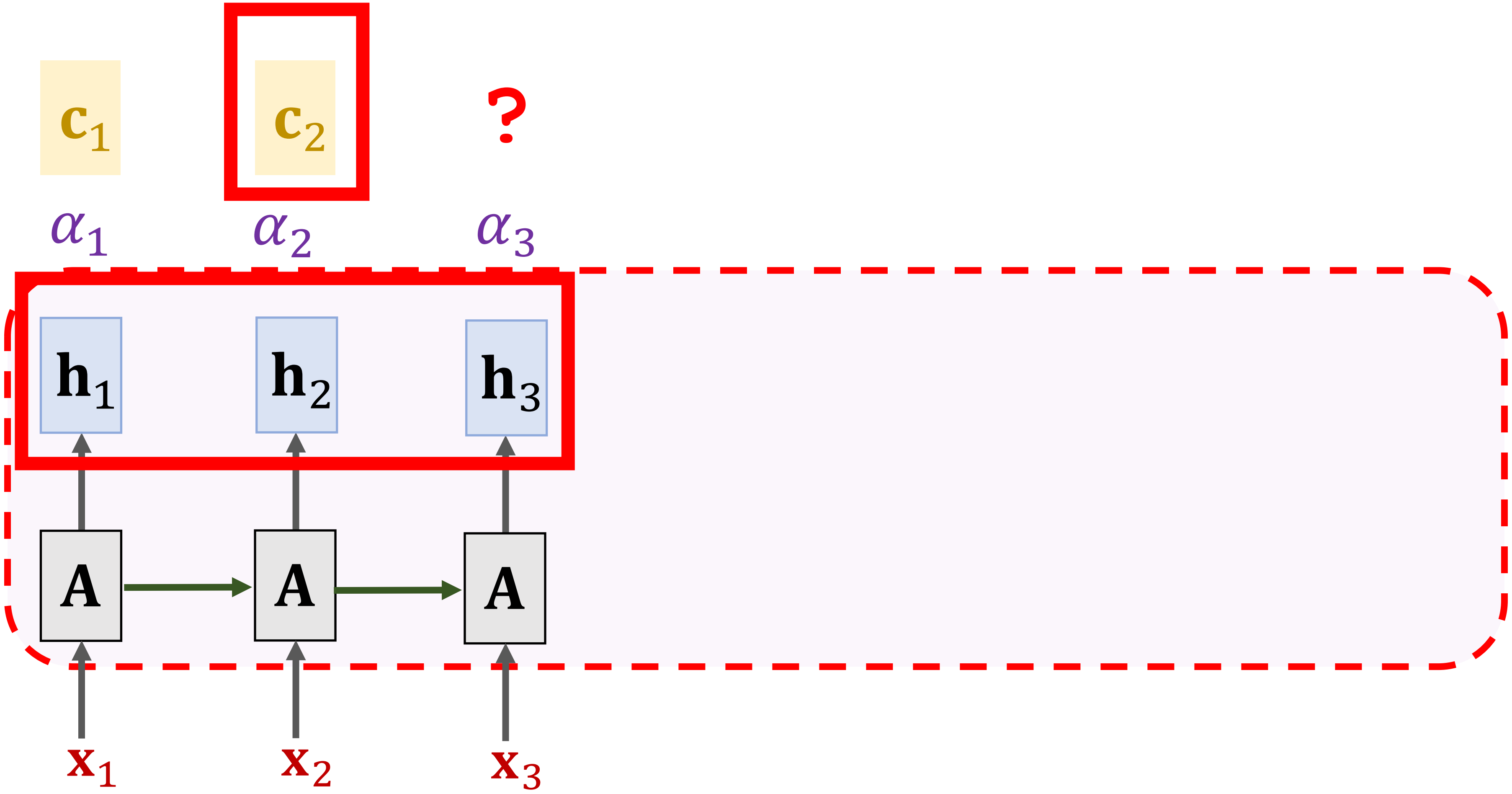

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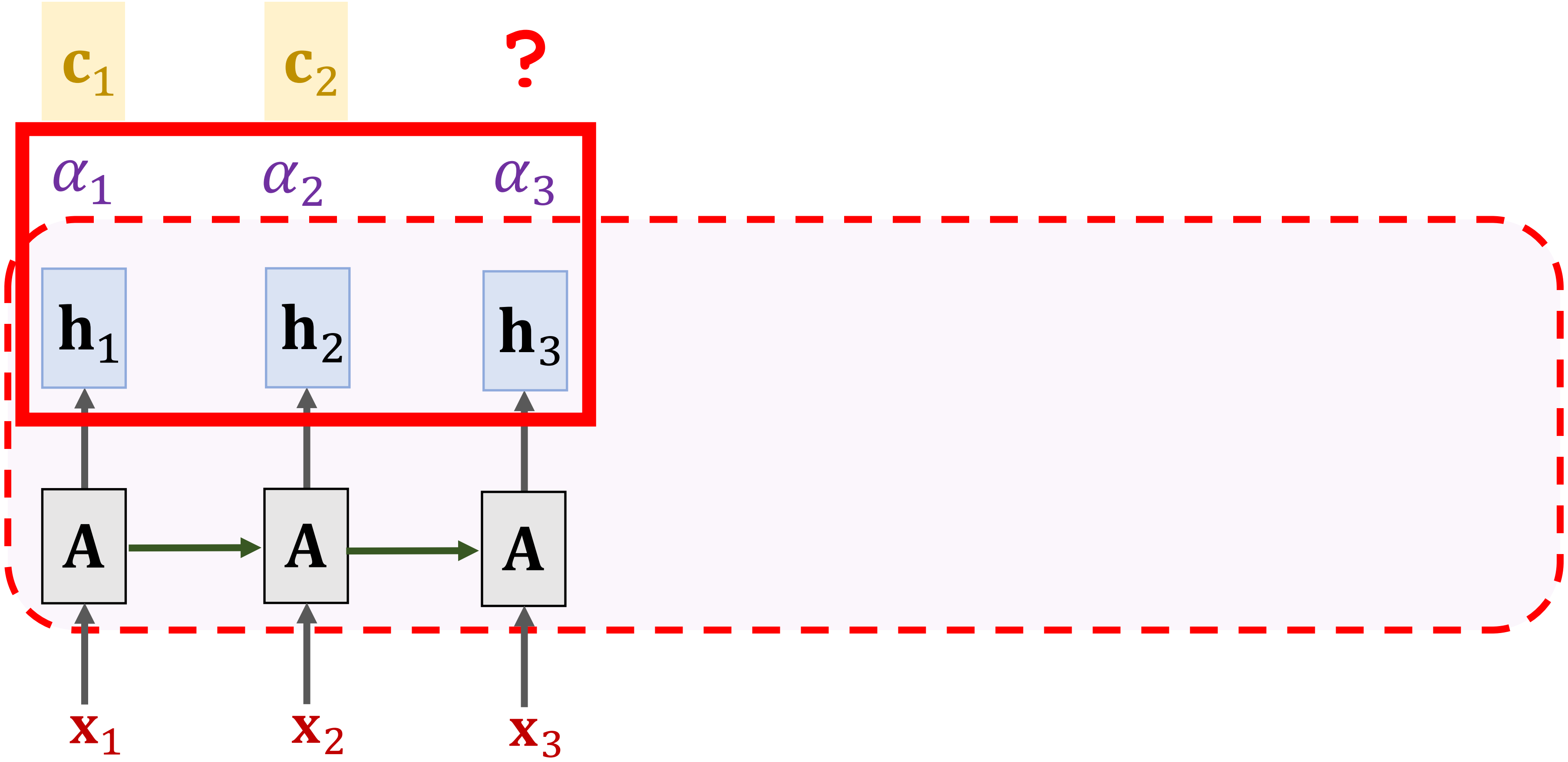

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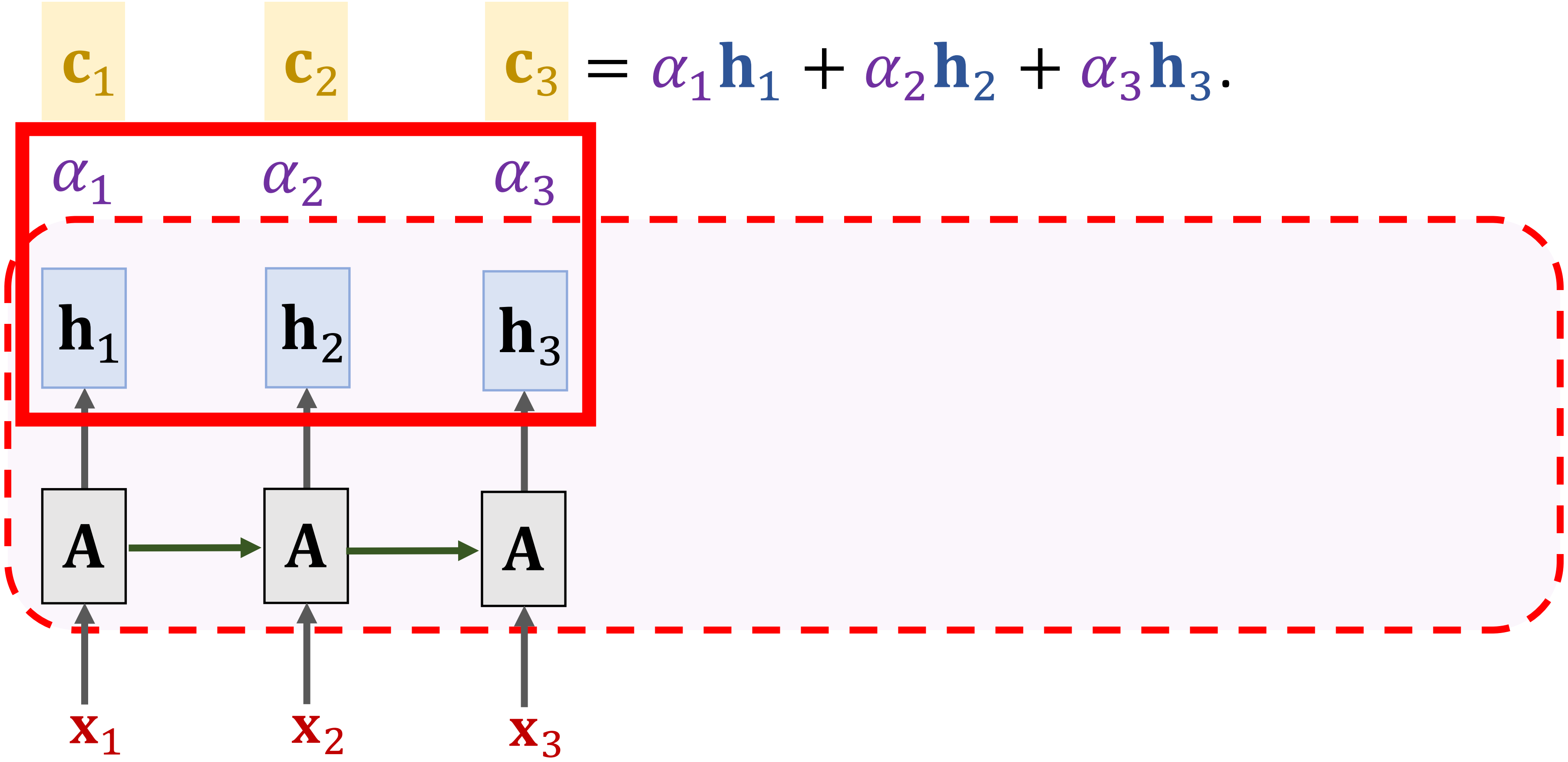
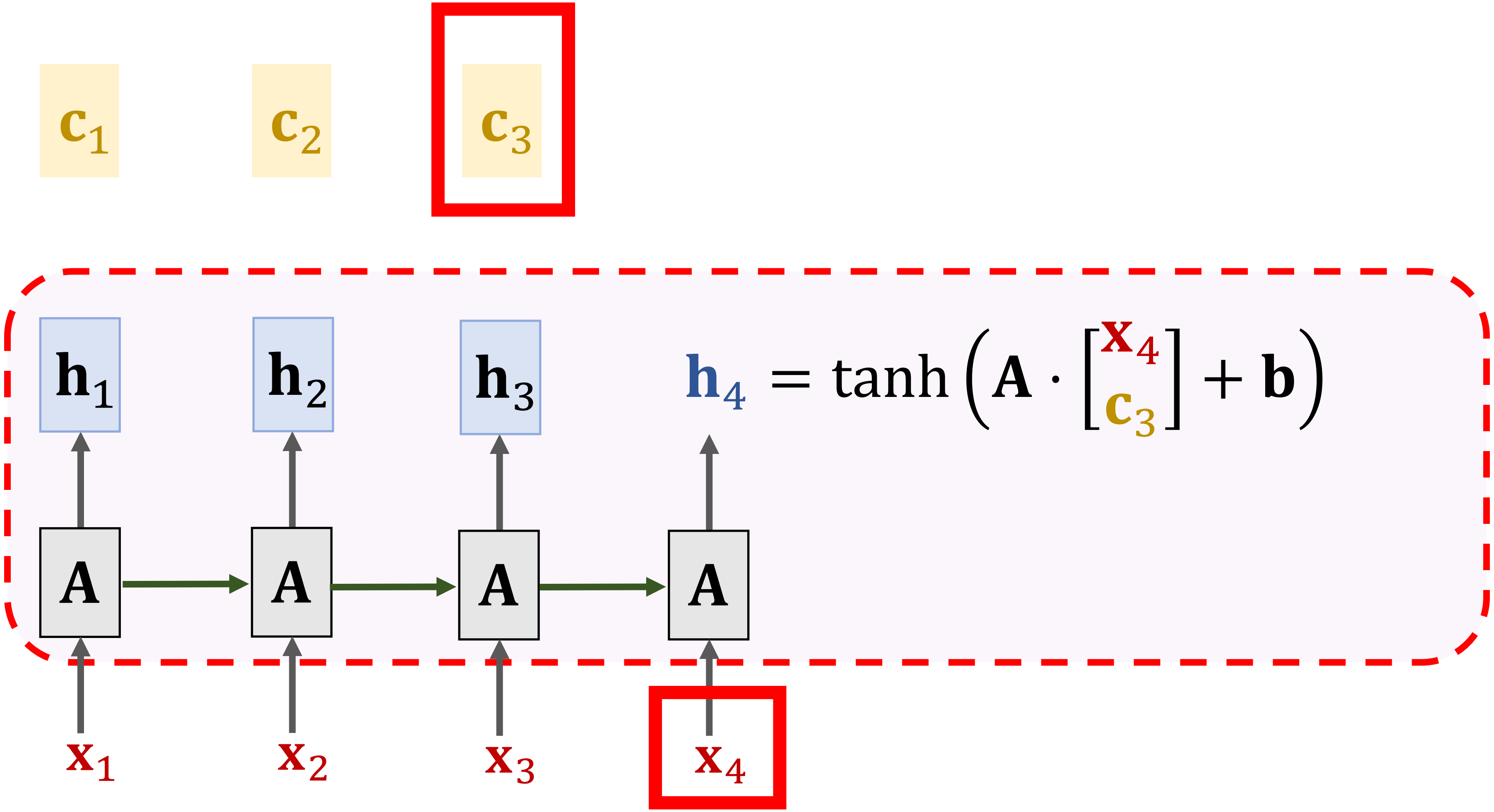


$\mathbf{c}_3 = \alpha_1 \mathbf{h}_1 + \alpha_2 \mathbf{h}_2 + \alpha_3 \mathbf{h}_3.$

# SimpleRNN + Self-Attention



$$\mathbf{h}_4 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_4 \\ \mathbf{c}_3 \end{bmatrix} + \mathbf{b}\right)$$

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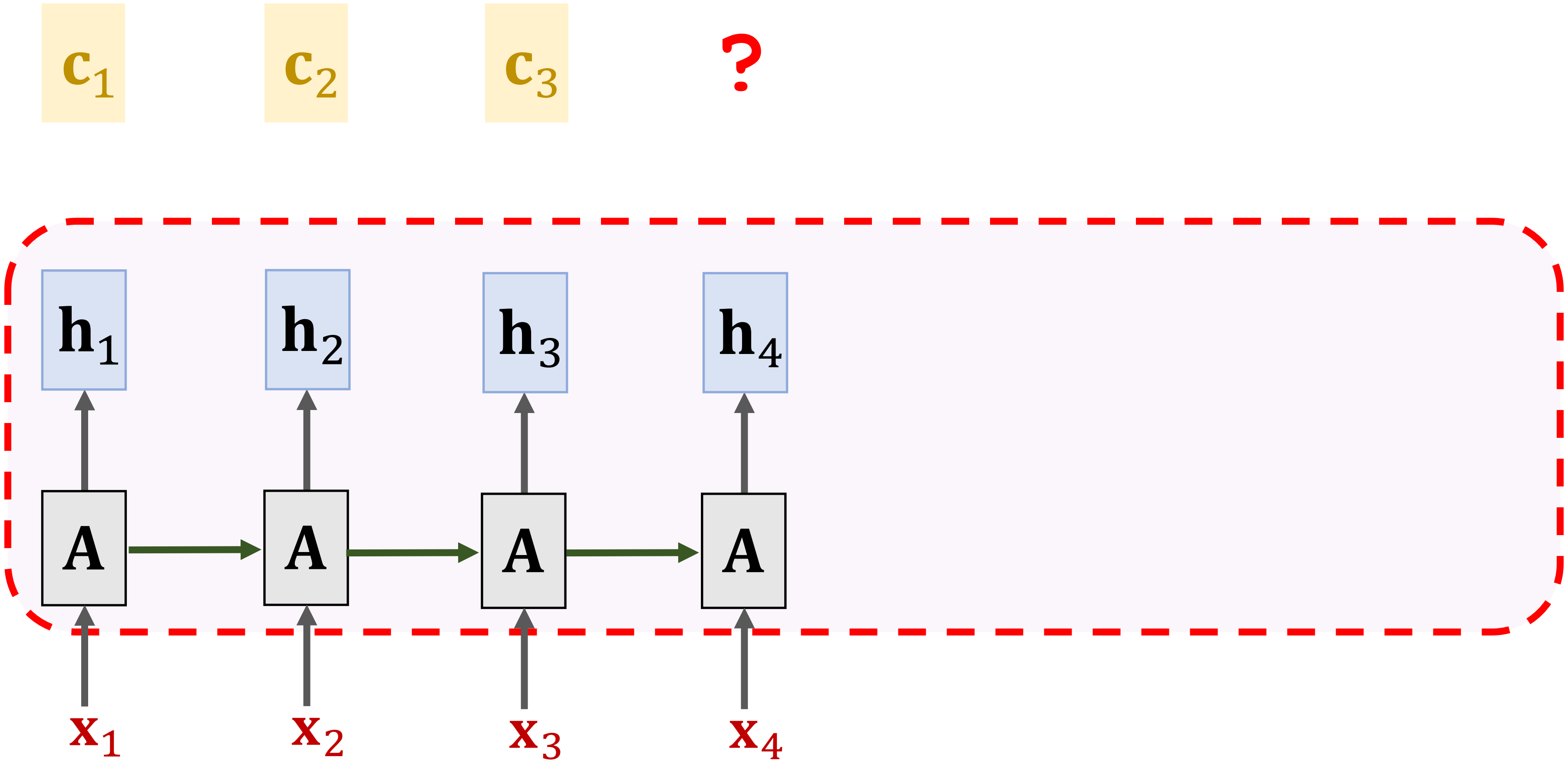

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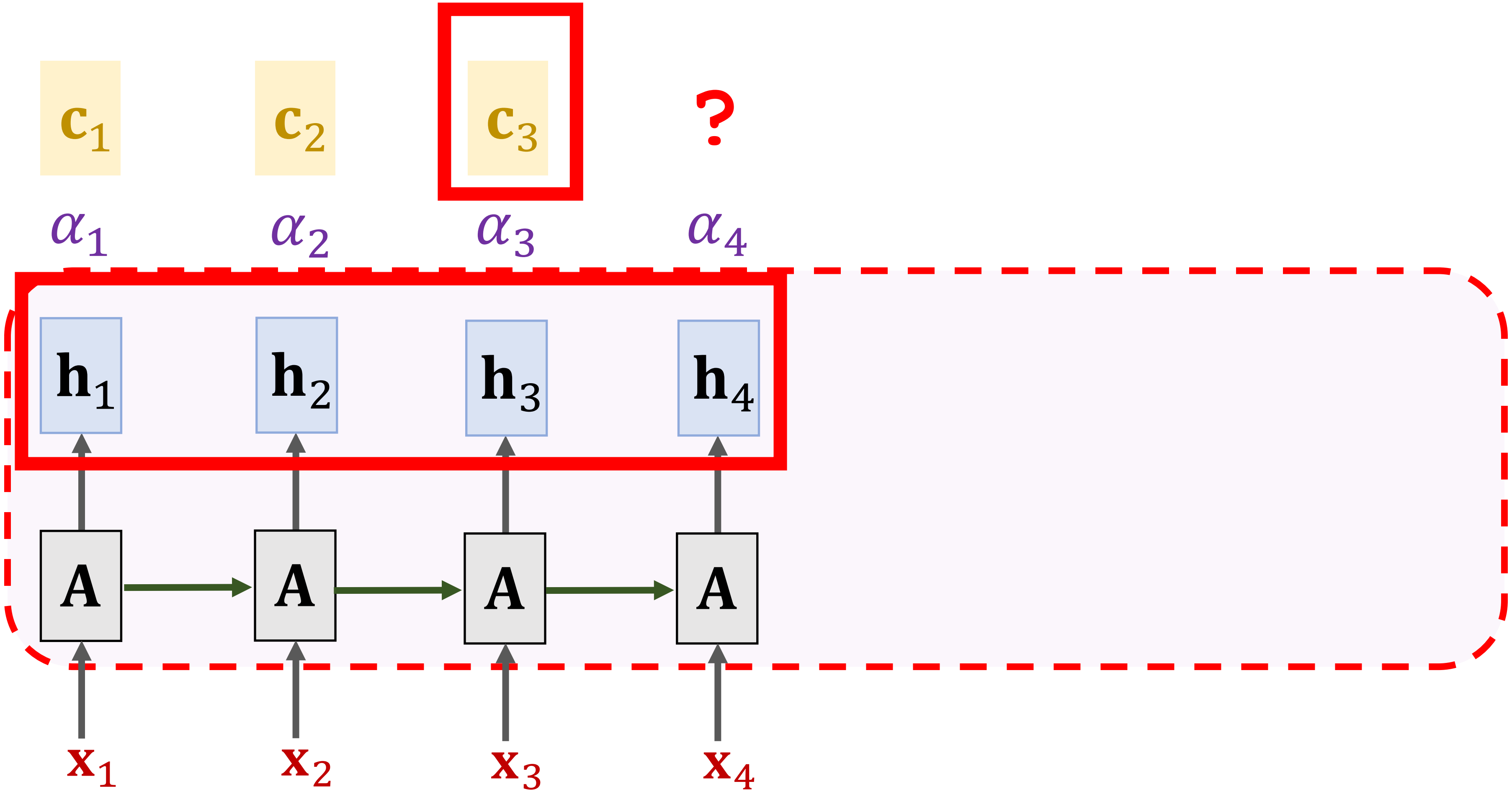

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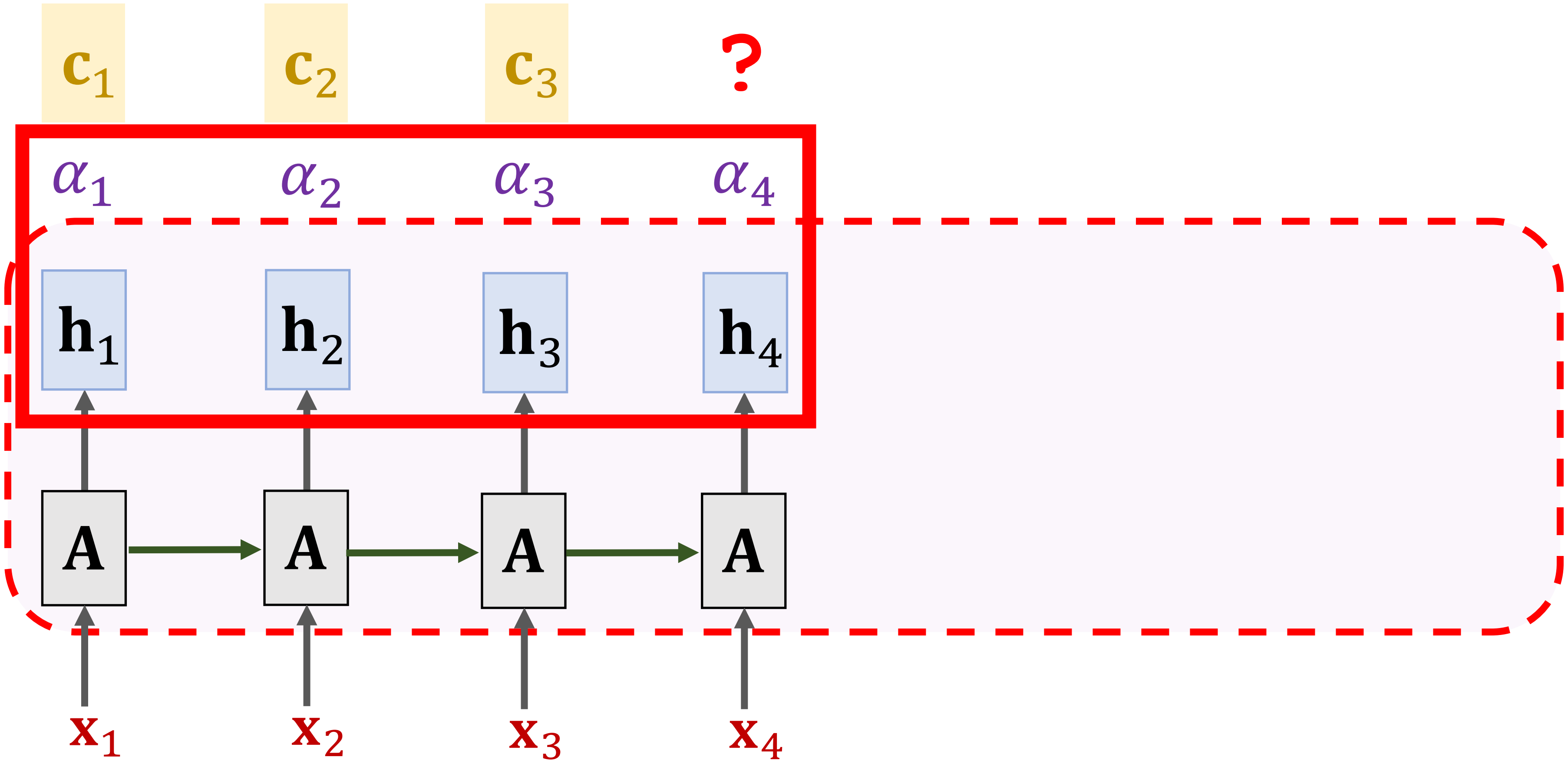

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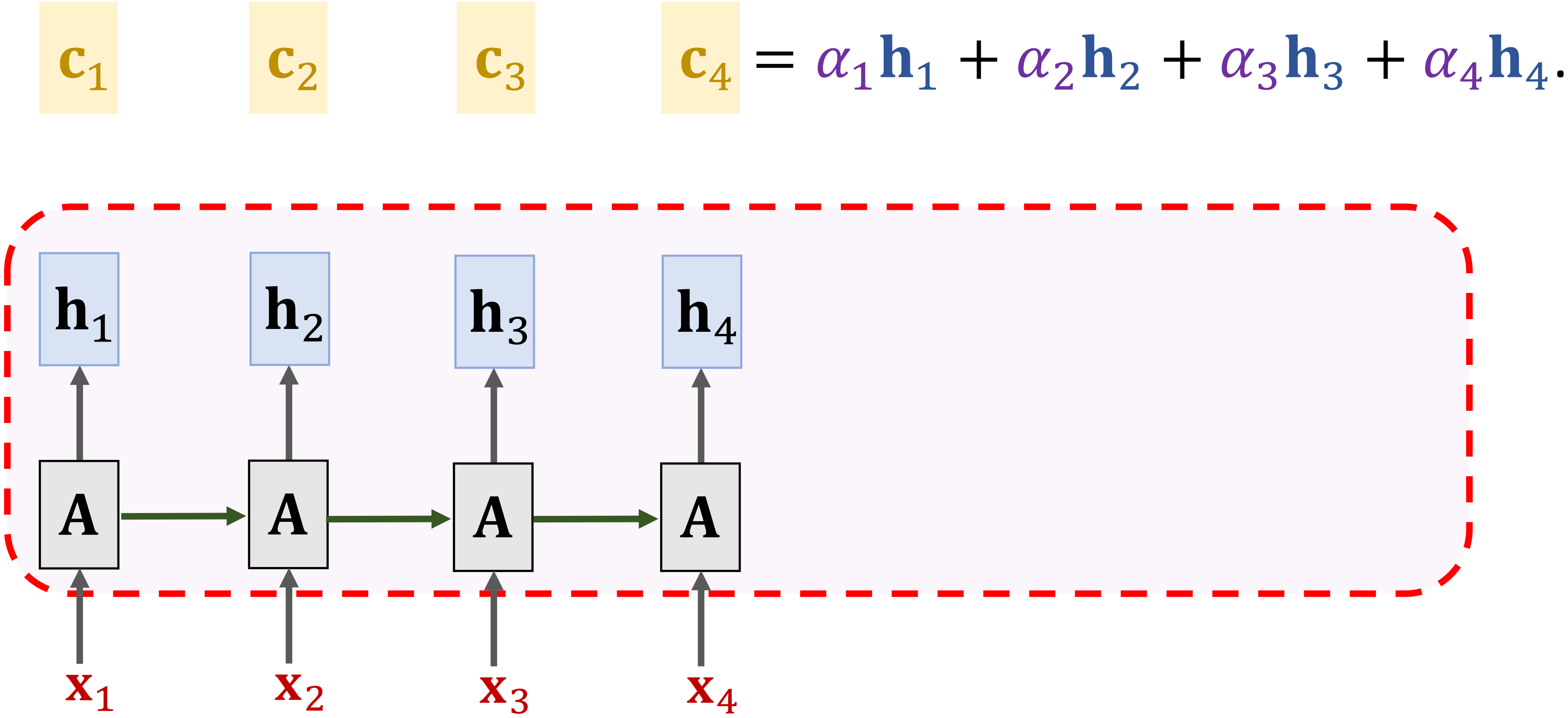
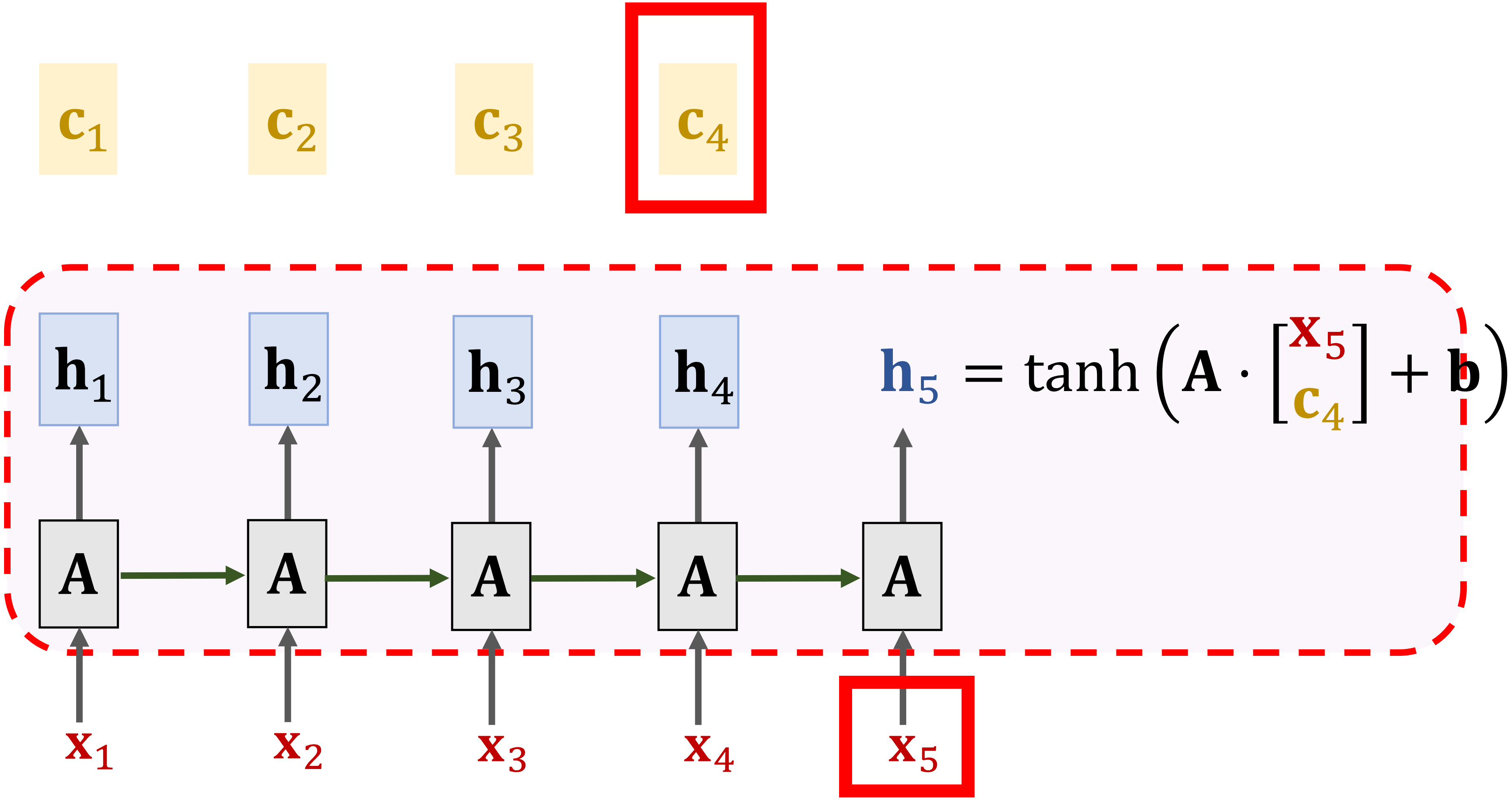


$$\mathbf{c}_4 = \alpha_1 \mathbf{h}_1 + \alpha_2 \mathbf{h}_2 + \alpha_3 \mathbf{h}_3 + \alpha_4 \mathbf{h}_4.$$

# SimpleRNN + Self-Attention



$$\mathbf{h}_5 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_5 \\ \mathbf{c}_4 \end{bmatrix} + \mathbf{b}\right)$$

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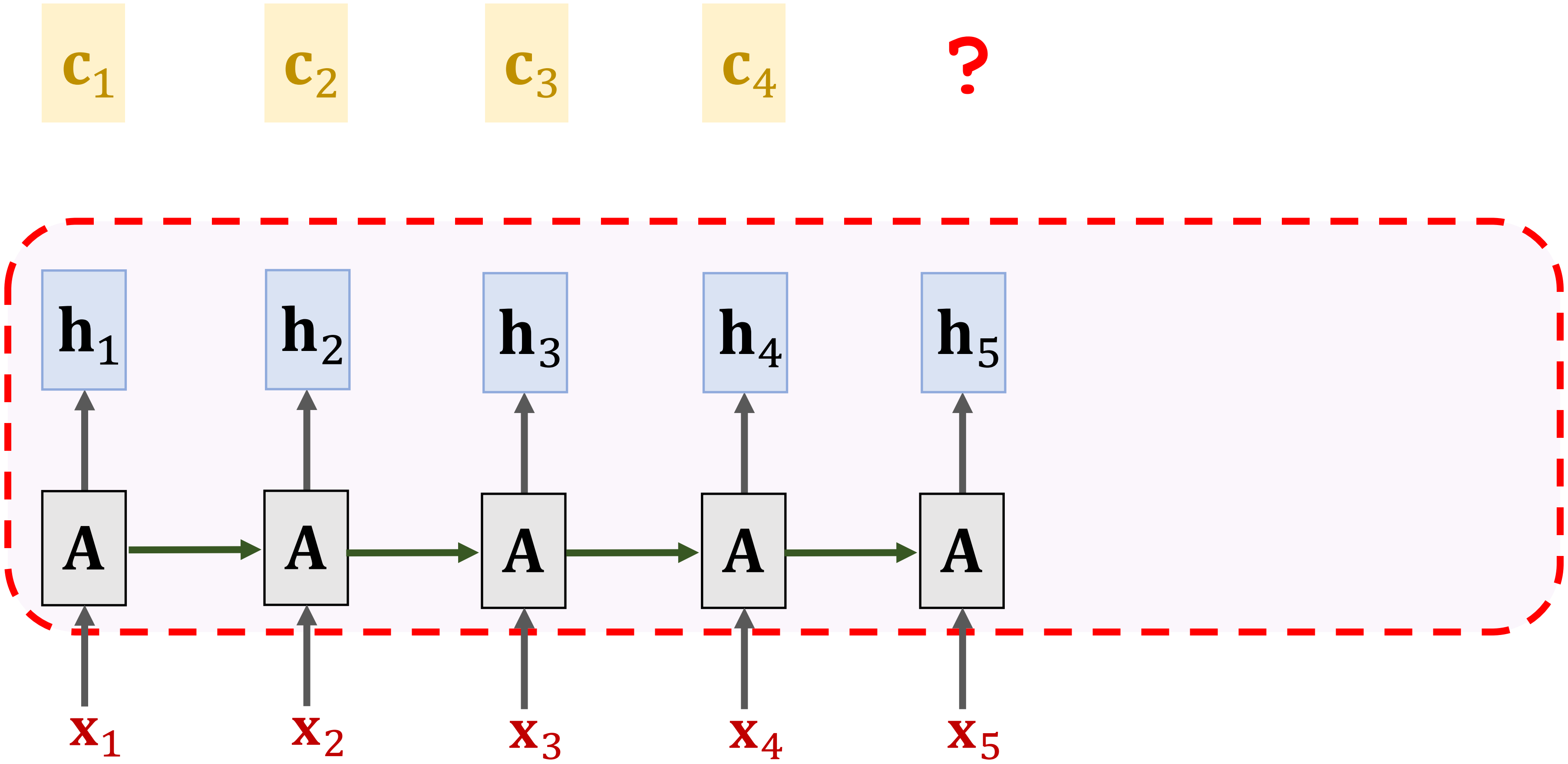

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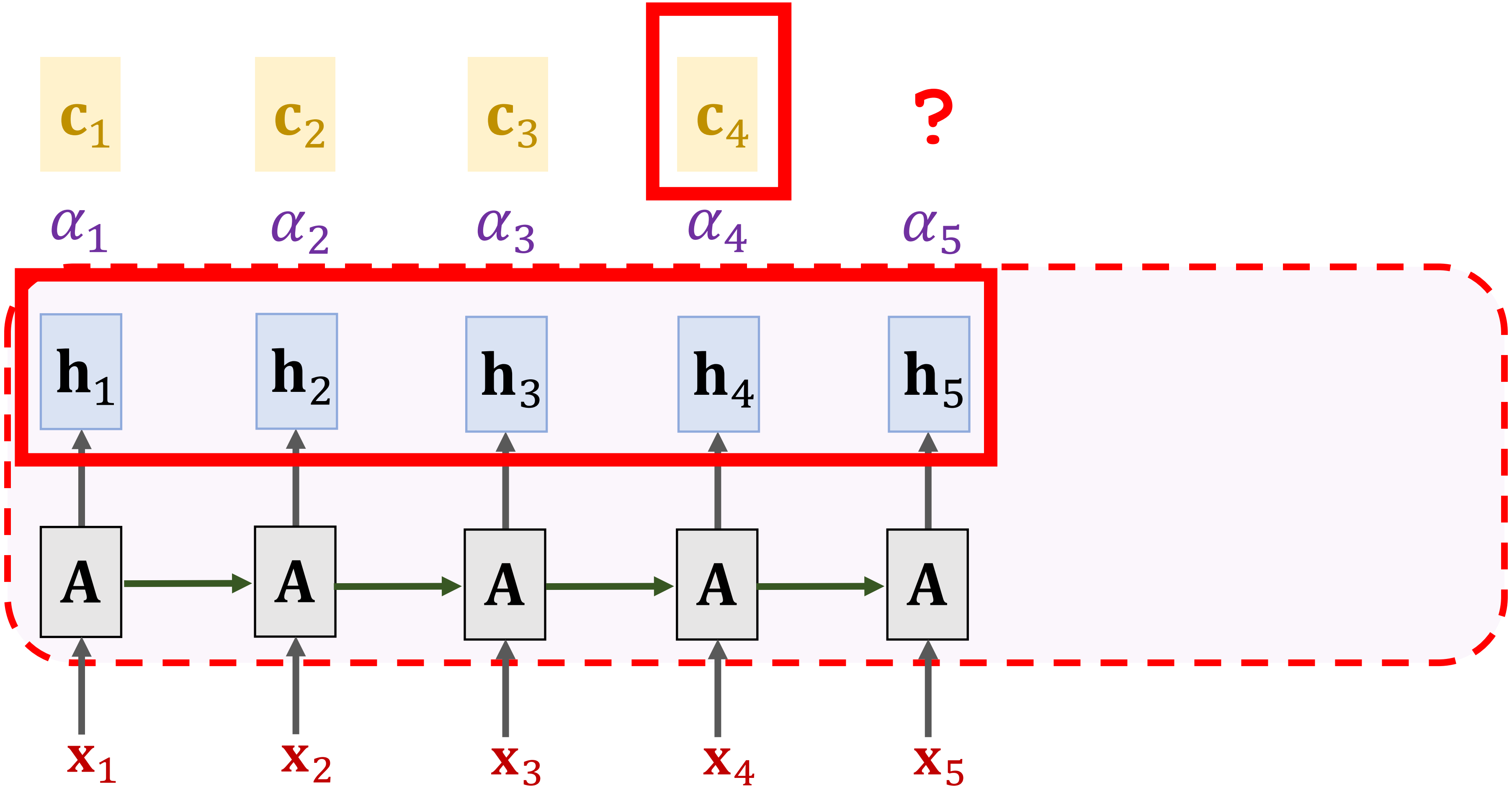

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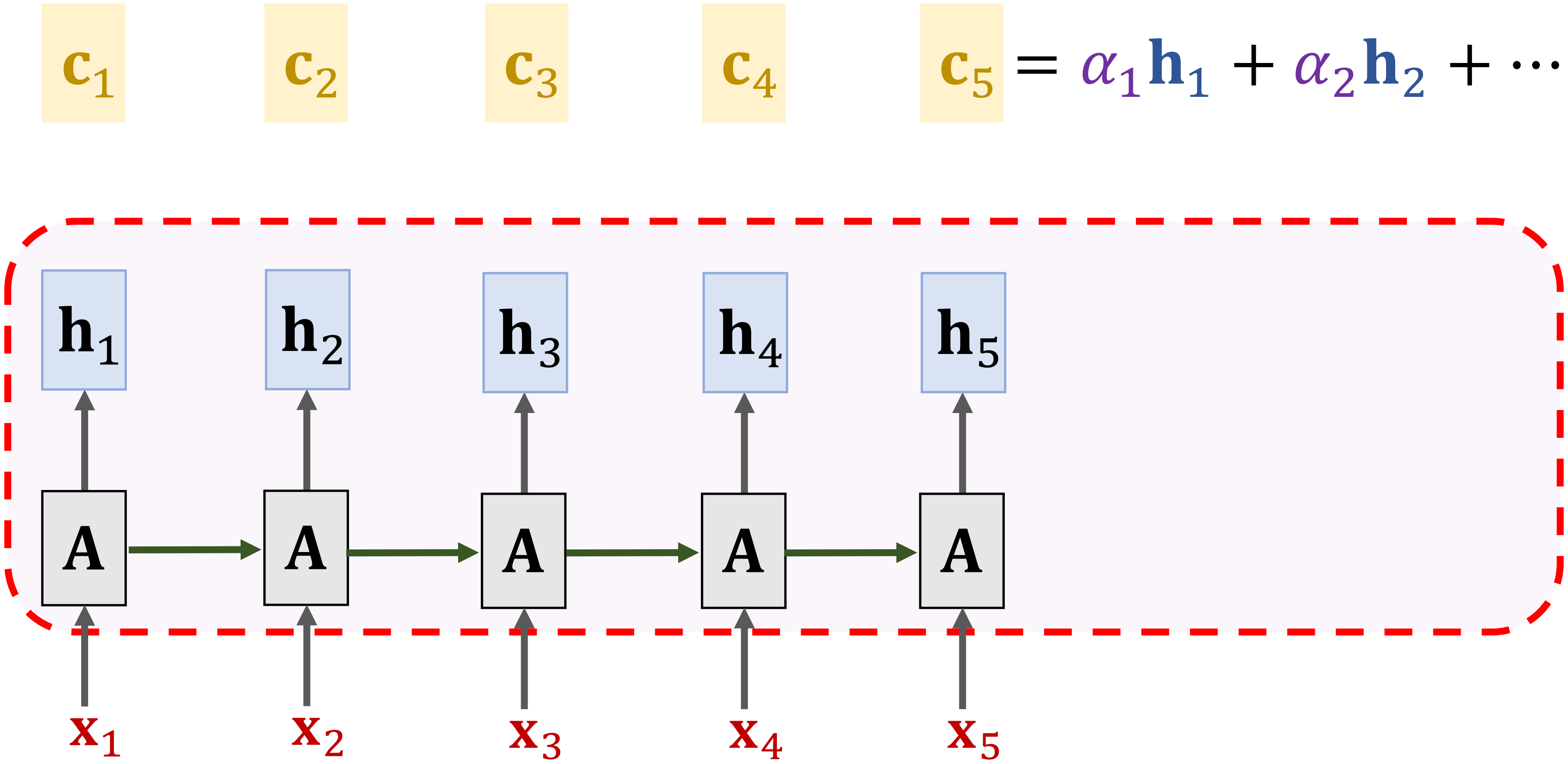
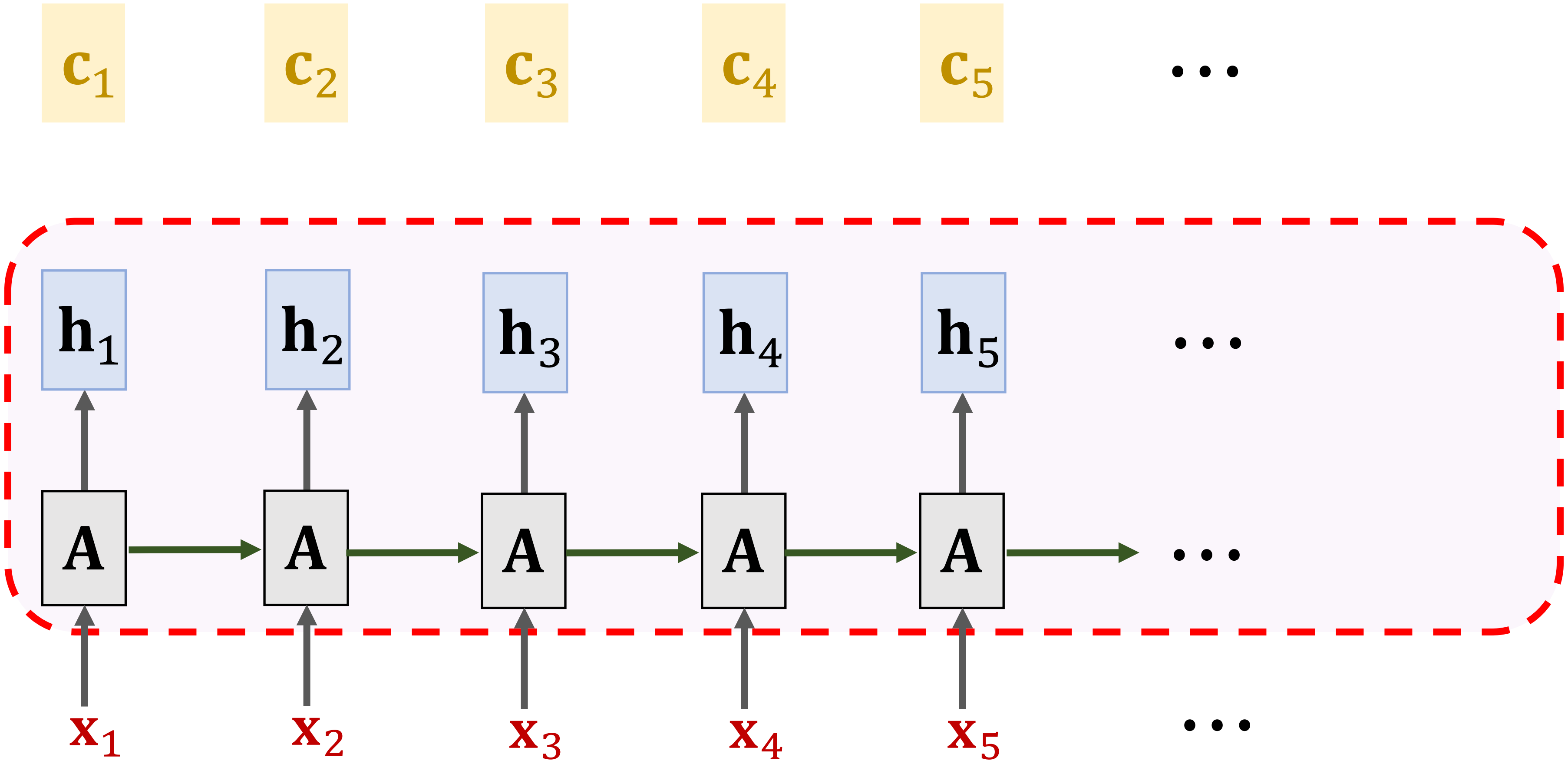


$$\mathbf{c}_5 = \alpha_1 \mathbf{h}_1 + \alpha_2 \mathbf{h}_2 + \cdots + \alpha_5 \mathbf{h}_5 .$$

# SimpleRNN + Self-Attention



# Summary

- With self-attention, RNN is less likely to forget.

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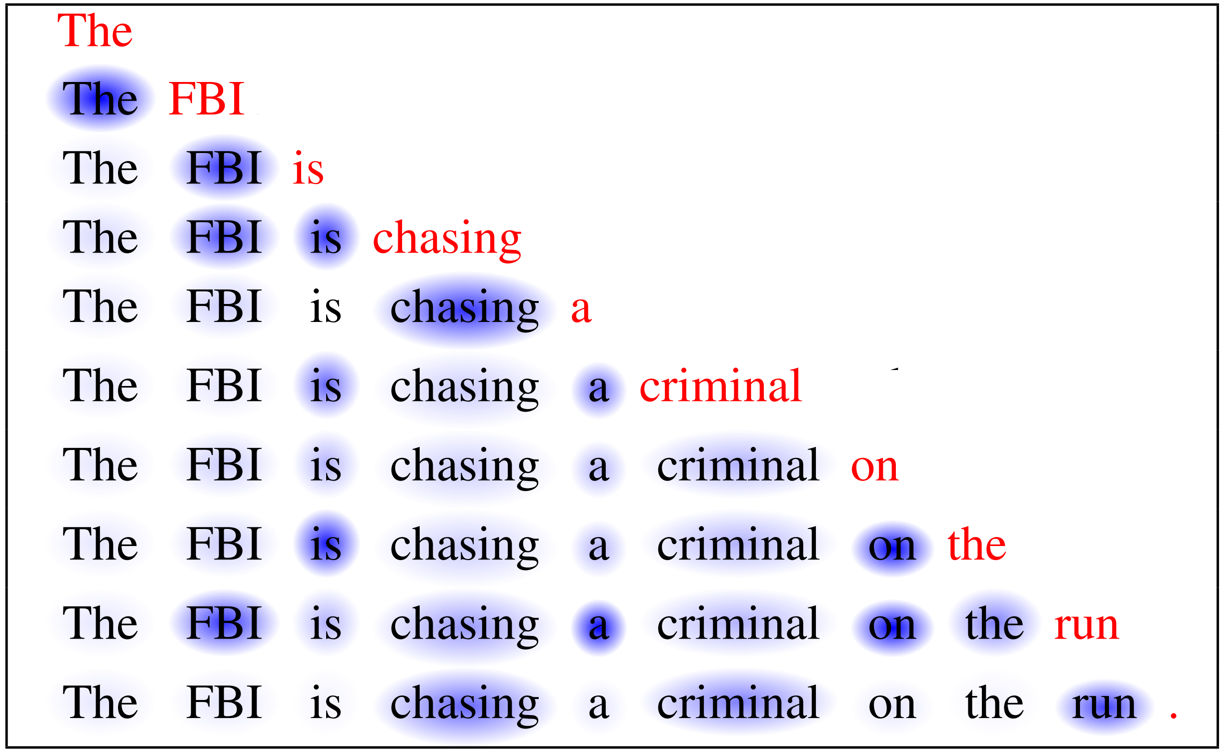
- With self-attention, RNN is less likely to forget.
- Pay attention to the context relevant to the new input.



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The FBI is chasing a criminal

The FBI is chasing a criminal on

The FBI is chasing a criminal on the

The FBI is chasing a criminal on the run

The FBI is chasing a criminal on the run .

Figure is from the paper " Long Short-Term Memory-Networks for Machine Reading."

# Thank you!