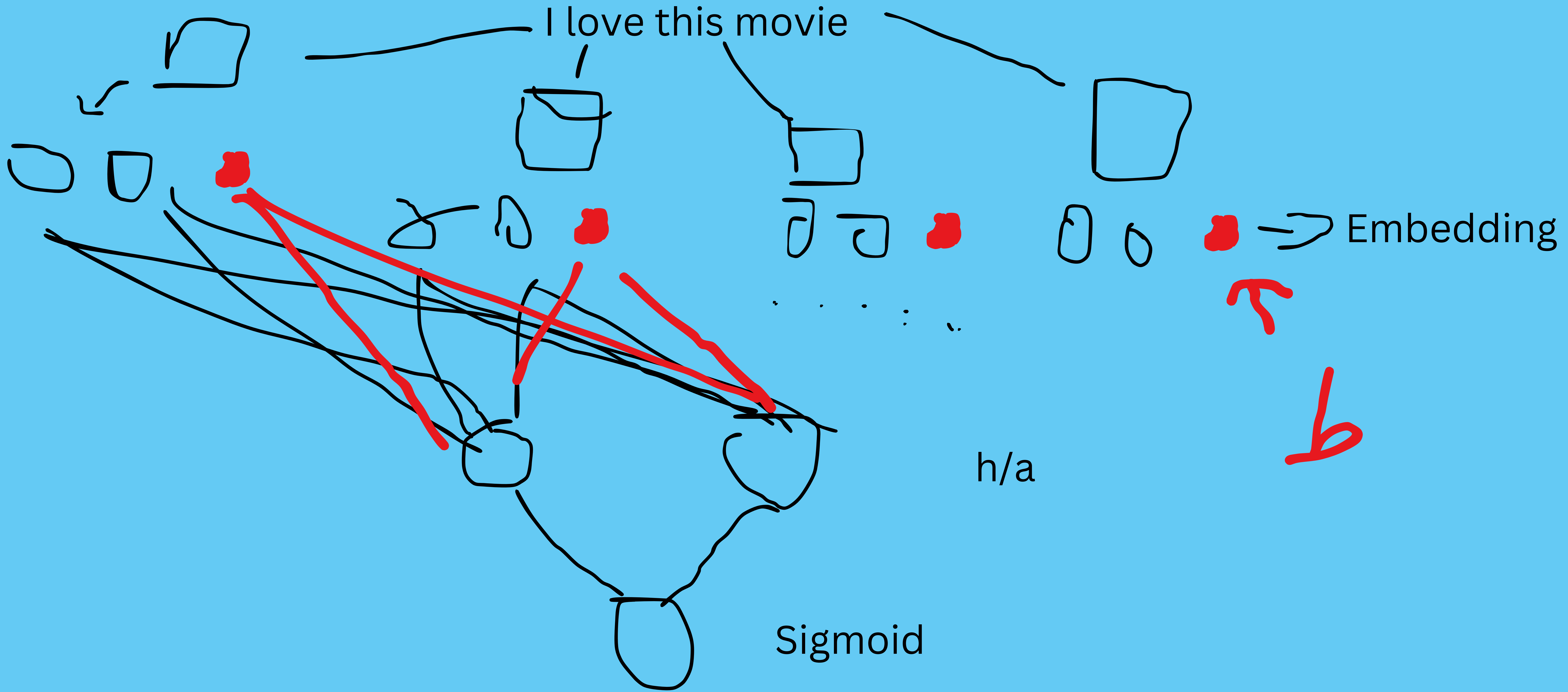
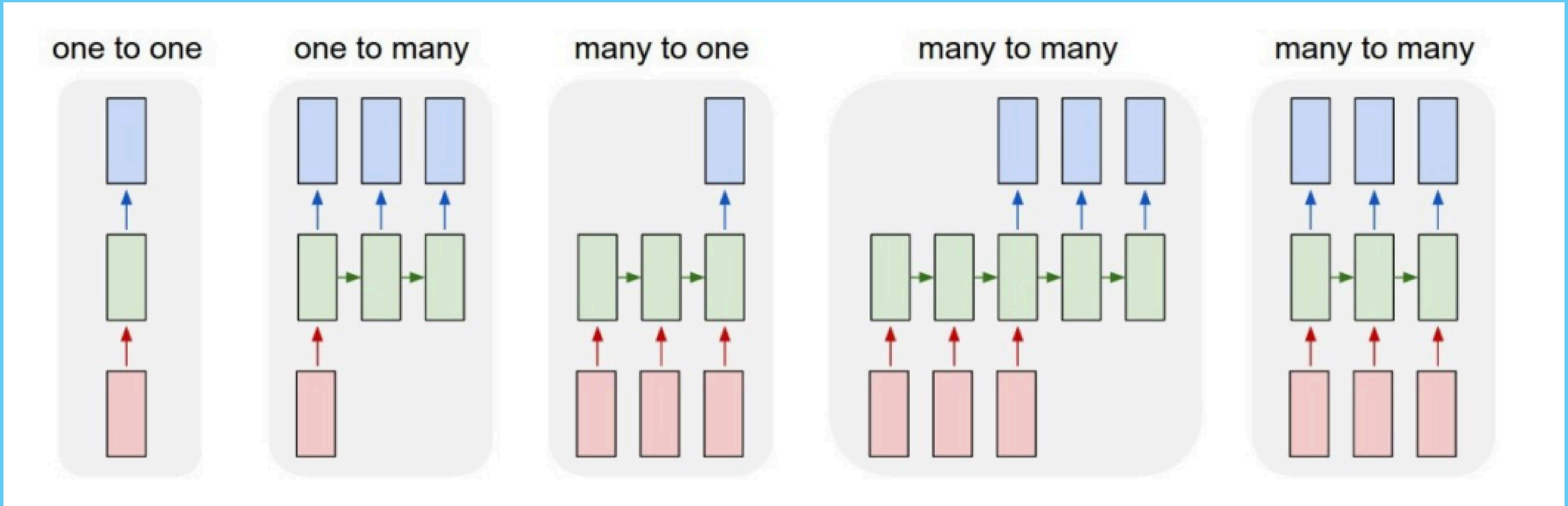
Recurrent Neural Network

) RNN (

Ý tưởng của sáng tạo RNN

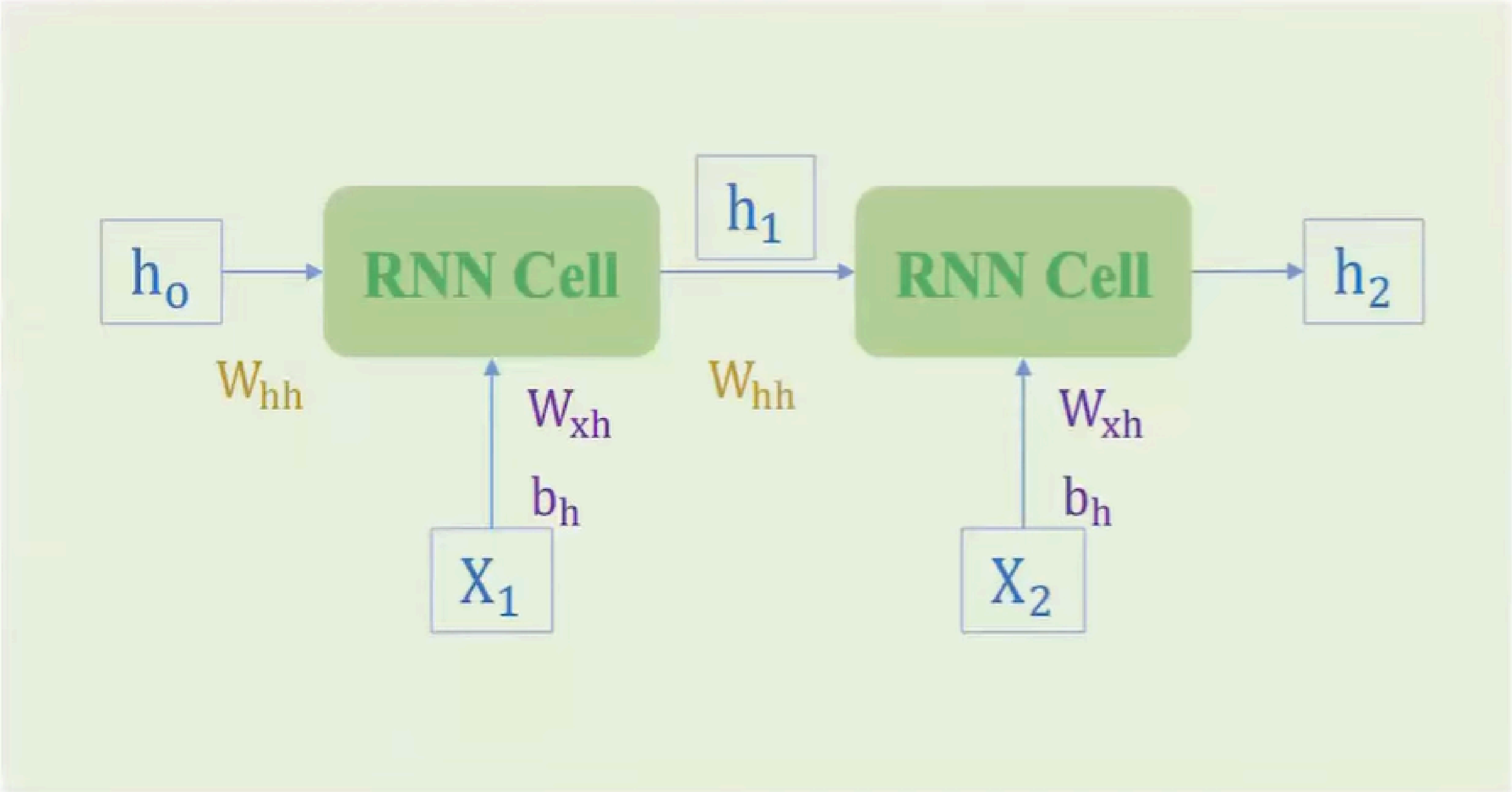


Phân loại bài toán RNN



Example

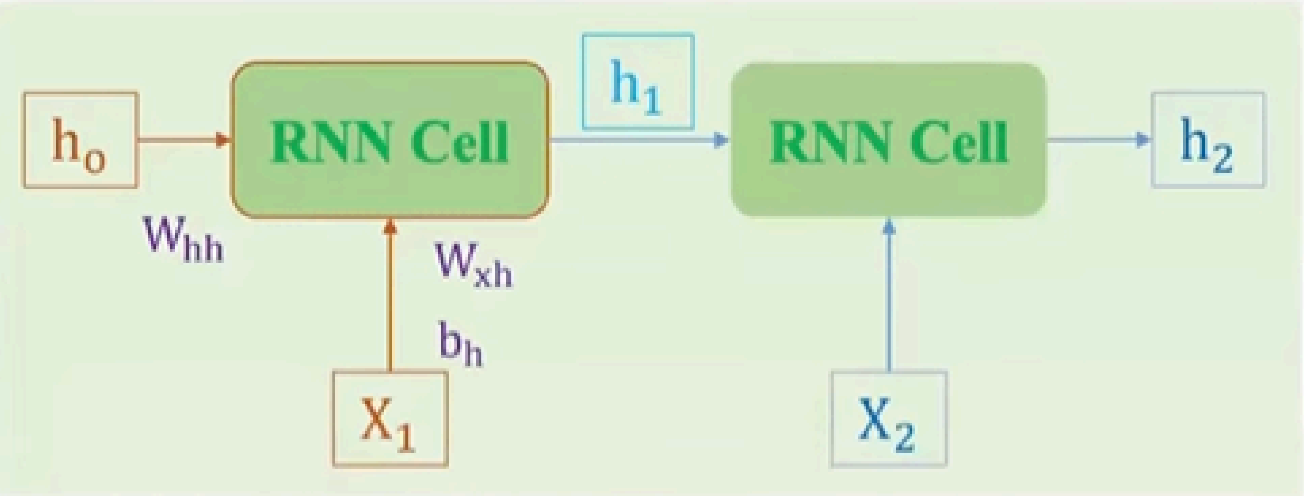
Classification and time-steps=2



$$h_1 = \tanh(X_1 W_{xh} + h_0 W_{hh} + b_h)$$

$$h_2 = \tanh(X_2 W_{xh} + h_1 W_{hh} + b_h)$$

Example

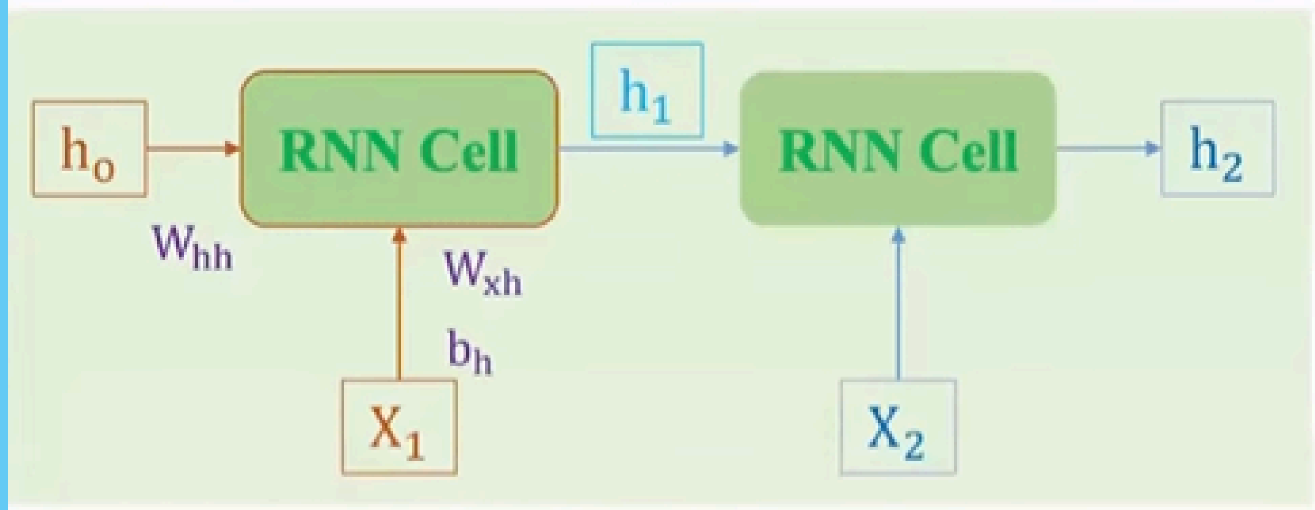


$$\mathbf{W_{hh}} = \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} \qquad \mathbf{b_h} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix}$$

$$\mathbf{W_{xh}} = \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix}$$

$$\mathbf{X} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1. & 3. & 2. & 1. \\ 0. & 4. & 1. & 2. \end{bmatrix} \qquad \mathbf{h_0} = [0. \quad 0. \quad 0.]$$

Example



$$\mathbf{W_{hh}} = \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} \qquad \mathbf{b_h} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix}$$

$$\mathbf{W_{xh}} = \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix}$$

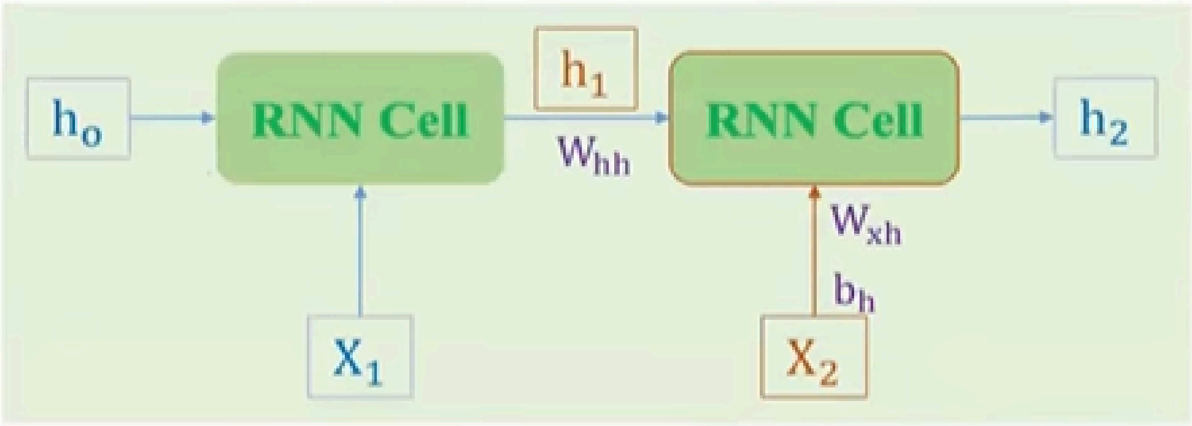
$$\mathbf{X} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1. & 3. & 2. & 1. \\ 0. & 4. & 1. & 2. \end{bmatrix} \qquad \mathbf{h_0} = [0. \quad 0. \quad 0.]$$

$$h_1 = \tanh(X_1 W_{xh} + h_0 W_{hh} + b_h)$$

$$= \tanh\left([1. \quad 3. \quad 2. \quad 1.] \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix} + [0. \quad 0. \quad 0.] \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} + \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix} \right)$$

$$= \tanh([-1.2 \quad -2.3 \quad 1.1]) = [-0.833 \quad -0.98 \quad 0.8]$$

Example



$$\mathbf{W_{hh}} = \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} \qquad \mathbf{b_h} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix}$$

$$\mathbf{W_{xh}} = \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix} \qquad \boldsymbol{h}_0 = [0. \quad 0. \quad 0.] \qquad \boldsymbol{h}_1 = [-0.833 \quad -0.98 \quad 0.8]$$

$$\mathbf{X} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1. & 3. & 2. & 1. \\ 0. & 4. & 1. & 2. \end{bmatrix}$$

$$h_2 = \tanh(X_2 W_{xh} + h_1 W_{hh} + b_h)$$

$$= \tanh\left([0. \quad 4. \quad 1. \quad 2.] \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix} + [-0.833 \quad -0.98 \quad 0.8] \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} + \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix} \right)$$

$$= \tanh([-2.67 \quad -2.09 \quad -0.109]) = [-0.99 \quad -0.97 \quad -0.109]$$

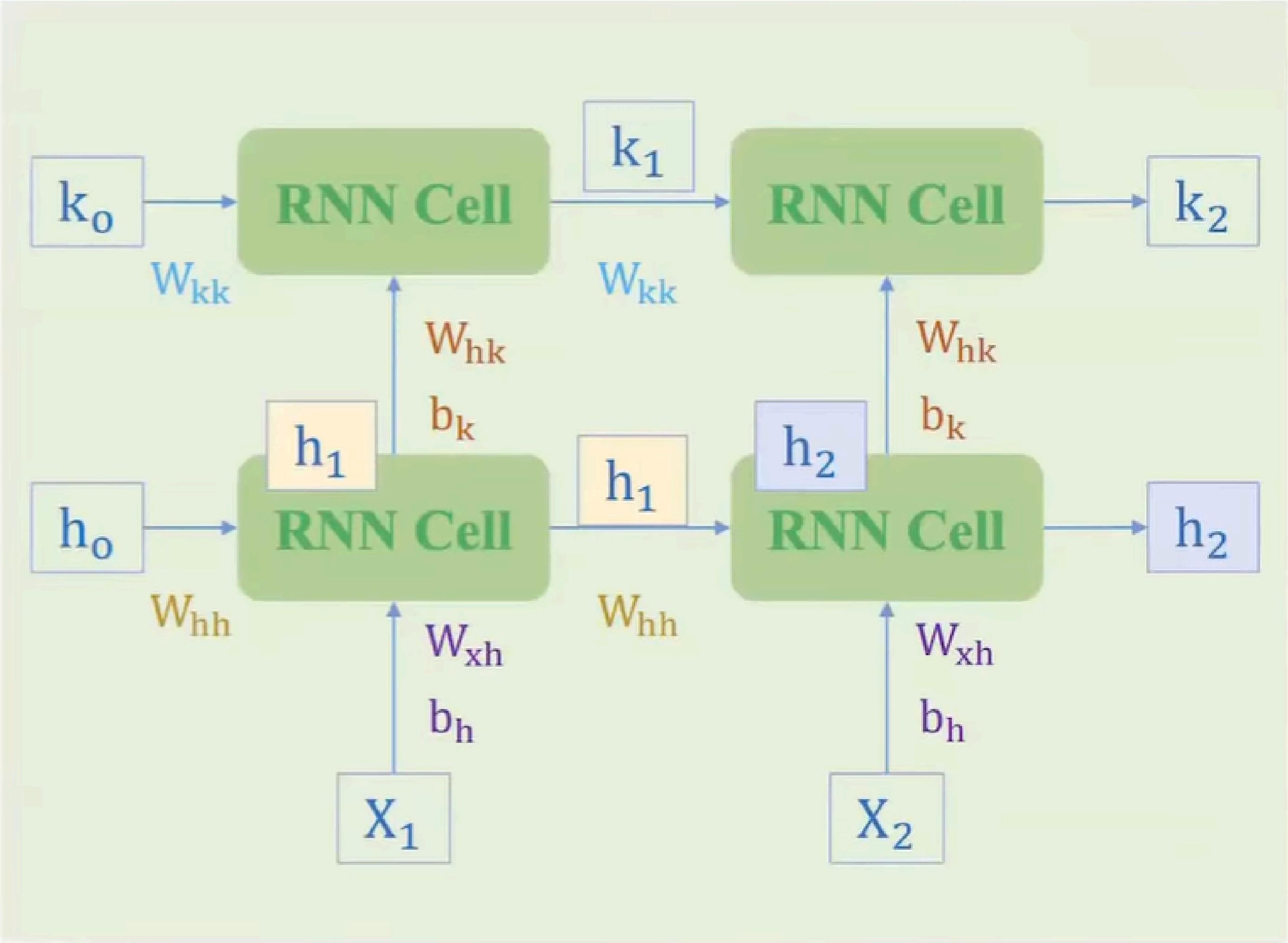
Multi layer

$$k_1 = \tanh(h_1 W_{hk} + h_0 W_{kk} + b_k)$$

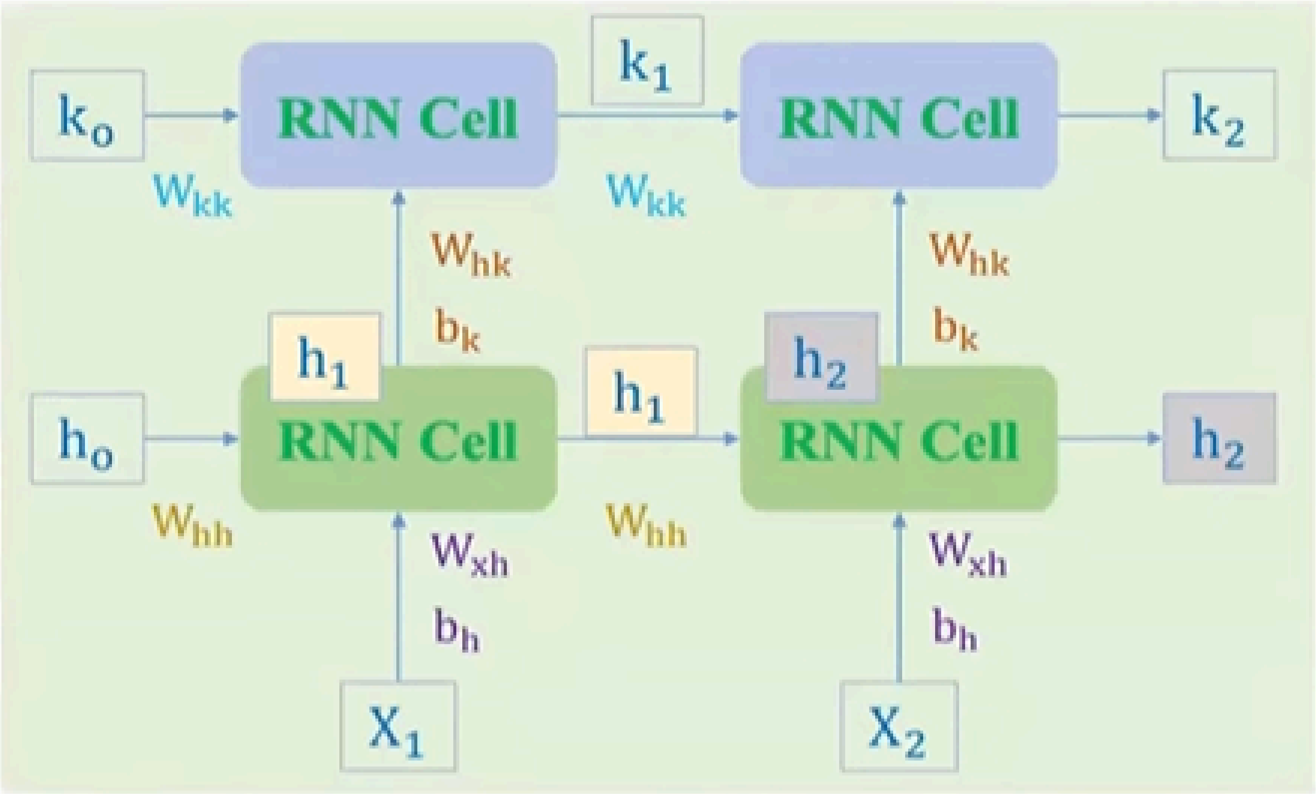
$$k_2 = \tanh(h_2 W_{hk} + h_1 W_{kk} + b_k)$$

$$h_1 = \tanh(X_1 W_{xh} + h_0 W_{hh} + b_h)$$

$$h_2 = \tanh(X_2 W_{xh} + h_1 W_{hh} + b_h)$$



Example



$$\mathbf{W_{hh}} = \begin{bmatrix} 0.9 & -0.1 & 0.1 \\ -0.1 & -0.9 & -0.3 \\ 0.1 & 0.3 & -0.9 \end{bmatrix} \qquad \mathbf{W_{kk}} = \begin{bmatrix} 0.1 & 0.9 \\ 0.9 & -0.1 \end{bmatrix}$$

$$\mathbf{W_{xh}} = \begin{bmatrix} -0.2 & -0.6 & 0.1 \\ -0.4 & -0.8 & -0.1 \\ 0.3 & 0.5 & 0.6 \\ -0.4 & -0.3 & 0.1 \end{bmatrix} \qquad \mathbf{W_{hk}} = \begin{bmatrix} -1.1 & 0.1 \\ 0.3 & -0.2 \\ -0.1 & 0.4 \end{bmatrix}$$

$$\mathbf{b_h} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix} \qquad \mathbf{b_k} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \end{bmatrix}$$

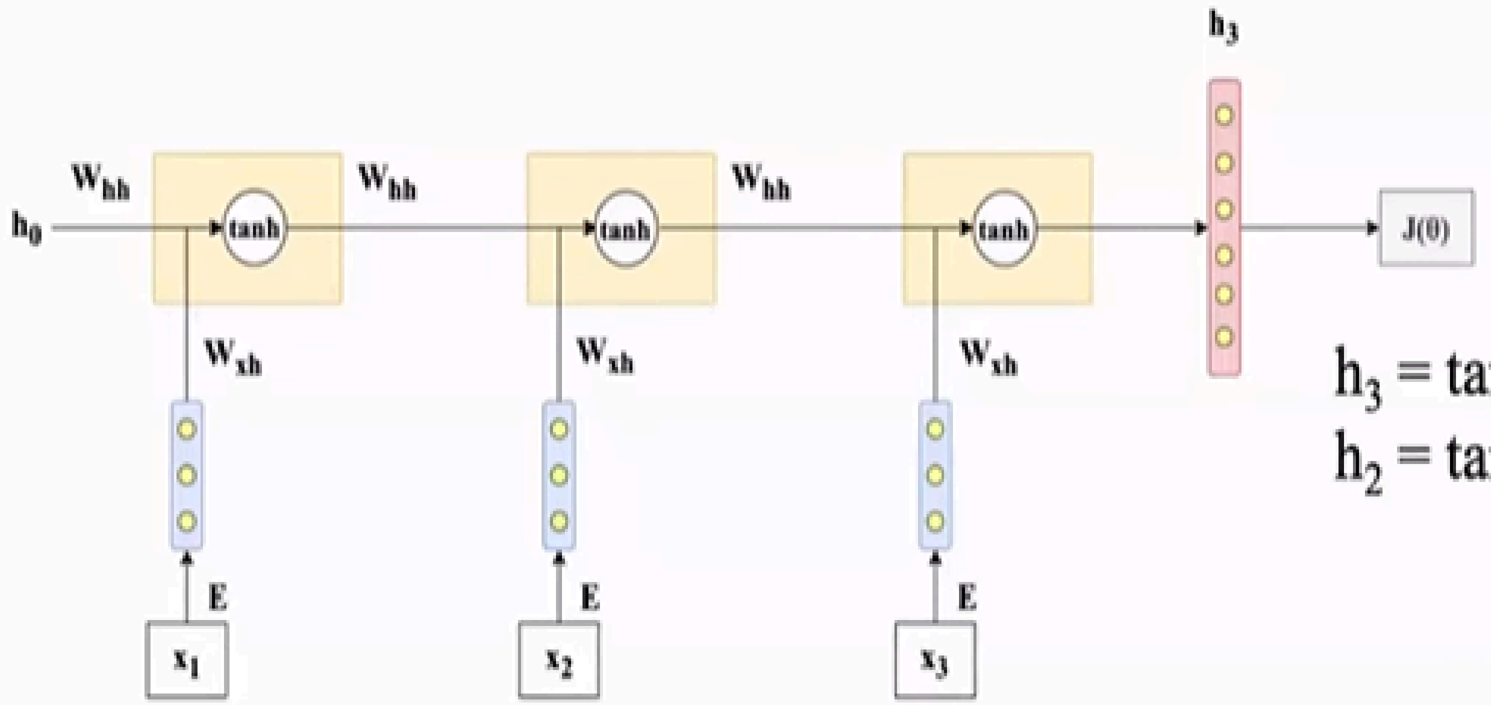
$$k_1 = \tanh(h_1 W_{hk} + h_0 W_{kk} + b_k)$$
$$= [0.49 \quad 0.407]$$

$$k_2 = \tanh(h_2 W_{hk} + h_1 W_{kk} + b_k)$$
$$= [0.84 \quad 0.42]$$

$$h_1 = \tanh(X_1 W_{xh} + h_0 W_{hh} + b_h)$$
$$= [-0.833 \quad -0.98 \quad 0.8]$$

$$h_2 = \tanh(X_2 W_{xh} + h_1 W_{hh} + b_h)$$
$$= [-0.99 \quad -0.97 \quad -0.109]$$

Backpropagation



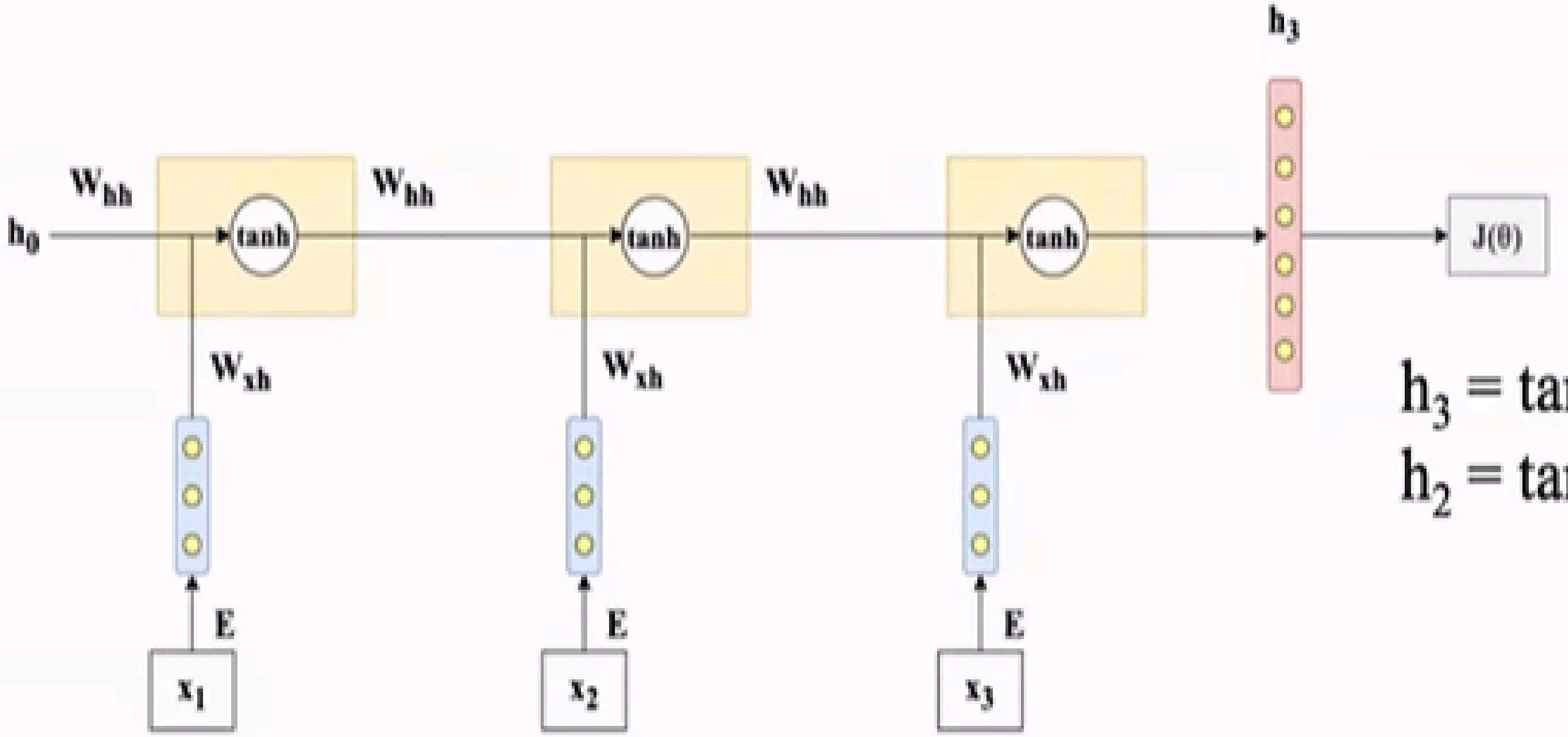
Loss: $J(\theta)$

Compute: $\frac{\partial J}{\partial W_{xh}}$

$$h_3 = \tanh\left(W_{hh}h_2 + W_{xh}x_3 + b_h\right)$$
$$h_2 = \tanh\left(W_{hh}h_1 + W_{xh}x_2 + b_h\right)$$

$$\frac{\partial J}{\partial W_{xh}} = \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial W_{xh}} + \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial h_2}$$

Backpropagation



Loss: $J(\theta)$

Compute: $\frac{\partial J}{\partial W_{xh}}$

$$h_3 = \tanh(W_{hh}h_2 + W_{xh}x_3 + b_h)$$
$$h_2 = \tanh(W_{hh}h_1 + W_{xh}x_2 + b_h)$$

$$\frac{\partial J}{\partial W_{xh}} = \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial W_{xh}} + \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial h_2}\left(\frac{\partial h_2}{\partial W_{xh}} + \frac{\partial h_2}{\partial h_1}\right) = \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial W_{xh}} + \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial h_2}\frac{\partial h_2}{\partial W_{xh}} + \frac{\partial J}{\partial h_3}\frac{\partial h_3}{\partial h_2}\frac{\partial h_2}{\partial h_1})$$