①

$$\frac{\partial L_{CE}}{\partial y_T} = -\frac{1}{y_T} \quad (t_T = 1)$$

$$t_{m \neq T} = 0$$

② $T = K$:

$$\frac{\partial y_T}{\partial z_K} = \frac{\partial y_K}{\partial z_K} = \frac{\partial}{\partial z_K}\left(\frac{e^{z_K}}{\sum_{k'} e^{z_{k'}}}\right)$$

$$= \frac{e^{z_K} \cdot \sum_{k'} e^{z_{k'}} - e^{z_K} \cdot e^{z_K}}{\left(\sum_{k'} e^{z_{k'}}\right)^2}$$

$$= \frac{e^{z_K}\left(\sum_{k'} e^{z_{k'}} - e^{z_K}\right)}{\sum_{k'} e^{z_{k'}} \cdot \sum_{k'} e^{z_{k'}}}$$

$$= y_K \cdot (1 - y_K)$$

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$T \neq K$:

$$\frac{\partial y_T}{\partial z_K} = \frac{\partial}{\partial z_K}\left(\frac{e^{z_T}}{\sum_{K'} e^{z_{K'}}}\right)$$

$$= \frac{-e^{z_T} \cdot e^{z_K}}{\left(\sum_{K'} e^{z_{K'}}\right)^2}$$

$$= -y_T \cdot \frac{e^{z_K}}{\left(\sum_{K} e^{z_{K'}}\right)}$$

$$= -y_T \cdot y_K$$

(3). if $t_K = 1$, $(T = K)$

$$\frac{\partial L_{CE}}{\partial z_K} = \frac{\partial L_{CE}}{\partial y_T} \cdot \frac{\partial y_T}{\partial z_K} = -\frac{1}{y_K} \cdot y_K(1 - y_K)$$

$$= (y_K - 1)$$

$$= y_K - t_K$$

if $t_K \neq 1$, $(T \neq K)$

$(t_K = 0)$

$$\frac{\partial L_{CE}}{\partial z_K} = \frac{\partial L_{CE}}{\partial y_T} \cdot \frac{\partial y_T}{\partial z_K} = -\frac{1}{y_T} \cdot (-y_T \cdot y_K)$$

$$= y_K$$

$$= y_K - 0$$

$$= \underline{y_K - t_K}$$

④ $$\frac{\partial z_K}{\partial W} = x.$$

⑤ $$\frac{\partial L_{CE}}{\partial W} = \frac{\partial L_{CE}}{\partial z_K} \cdot \frac{\partial z_K}{\partial W}$$

$$= (y_K - t_K) \cdot x.$$