

1 SchemeCANIFPCT

1.1 $\text{Setup}(l) \rightarrow (mpk, msk)$

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$$\begin{aligned}
& p \leftarrow \|\mathbb{G}\| \\
& \text{generate } g_1, g_3 \in \mathbb{G}_1 \text{ randomly} \\
& \text{generate } g_2 \in \mathbb{G}_2 \text{ randomly} \\
& \text{generate } r, s, t, \omega, t_1, t_2, t_3, t_4 \in \mathbb{Z}_r \text{ randomly} \\
& R \leftarrow g_1^r \\
& S \leftarrow g_2^s \\
& T \leftarrow g_1^t \\
& \Omega \leftarrow e(g_1, g_2)^{t_1 t_2 \omega} \\
& v_1 \leftarrow g_2^{t_1} \\
& v_2 \leftarrow g_2^{t_2} \\
& v_3 \leftarrow g_2^{t_3} \\
& v_4 \leftarrow g_2^{t_4} \\
& mpk \leftarrow (g_1, g_2, p, g_3, H_1, H_2, H_3, H_4, R, S, T, \Omega, v_1, v_2, v_3, v_4) \\
& msk \leftarrow (r, s, t, \omega, t_1, t_2, t_3, t_4) \\
& \mathbf{return} \ (mpk, msk)
\end{aligned}$$


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1.2 KGen(ID_k) $\rightarrow sk_{ID_k}$

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generate  $k_i, x_i \in \mathbb{Z}_r$  randomly
 $z_i \leftarrow (r - x_i)(sx_i)^{-1} \in \mathbb{Z}_r$ 
 $Z_i \leftarrow g_1^{z_i} \in \mathbb{G}_1$ 
 $sk_{ID_i} \leftarrow k_i$ 
 $ek_{ID_i} \leftarrow (x_i, Z_i)$ 
 $HI \leftarrow h_1^{I_1} h_2^{I_2} \dots h_k^{I_k}$ 
 $sk_{ID_k} \leftarrow (g_2^{\frac{r}{b_1}} \cdot HI^{\frac{r}{b_1}} \cdot \bar{g}_3^r, g_2^{\frac{r}{b_2}} \cdot HI^{\frac{r}{b_2}} \cdot \bar{g}_3^r, g^r, h_{k+1}^{\frac{r}{b_1}}, h_{k+2}^{\frac{r}{b_1}}, \dots, h_l^{\frac{r}{b_1}}, h_{k+1}^{\frac{r}{b_2}}, h_{k+2}^{\frac{r}{b_2}}, \dots, h_l^{\frac{r}{b_l}}, h_{k+1}^{b_1^{-1}}, h_{k+2}^{b_1^{-1}}, \dots, h_l^{b_l^{-1}}, h_{k+1}^{b_2^{-1}}, h_{k+2}^{b_2^{-1}}, \dots, h_l^{b_l^{-1}})$ 
return  $sk_{ID_k}$ 

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1.3 DerivedKGen($sk_{ID_{k-1}}, ID_k$) $\rightarrow sk_{ID_k}$

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generate  $t \in \mathbb{Z}_r$  randomly
 $sk_{ID_k} \leftarrow (a_0 \cdot c_{0,k}^{I_k} \cdot (f_0 \cdot d_{0,k}^{I_k} \cdot \tilde{g}_3)^t, a_1 \cdot c_{1,k}^{I_k} \cdot (f_1 \cdot d_{1,k}^{I_k} \cdot \tilde{g}_3)^t, b \cdot g^t, c_{0,k+1} \cdot d_{0,k+1}^t, c_{0,k+2} \cdot d_{0,k+2}^t, \dots, c_{0,l} \cdot d_{0,l}^t, c_{1,k+1} \cdot d_{1,k+1}^t, c_{1,k+2} \cdot d_{1,k+2}^t, \dots, c_{1,l} \cdot d_{1,l}^t, d_{0,k+1}, d_{0,k+2}, \dots, d_{0,l}, d_{1,k+1}, d_{1,k+2}, \dots, d_{1,l}, f_0^{c_{0,k}}, f_1 \cdot c_{1,k}^{I_k})$ 
return  $sk_{ID_k}$ 

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1.4 $\text{Enc}(ID_k, M) \rightarrow CT$

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generate  $s_1, s_2 \in \mathbb{Z}_r$  randomly
 $CT \leftarrow (e(g_1, g_2)^{s_1+s_2} \cdot M, \bar{g}^{s_1}, \tilde{g}^{s_2}, (h_1^{I_1} h_2^{I_2} \dots h_k^{I_k} \cdot g_3)^{s_1+s_2})$ 
return  $CT$ 

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$$1.5 \quad \text{Dec}(CT, sk_{ID_k}) \rightarrow M$$
$$M \leftarrow \frac{e(b, D) \cdot A}{e(B, a_0) \cdot e(C, a_1)}$$

return M