

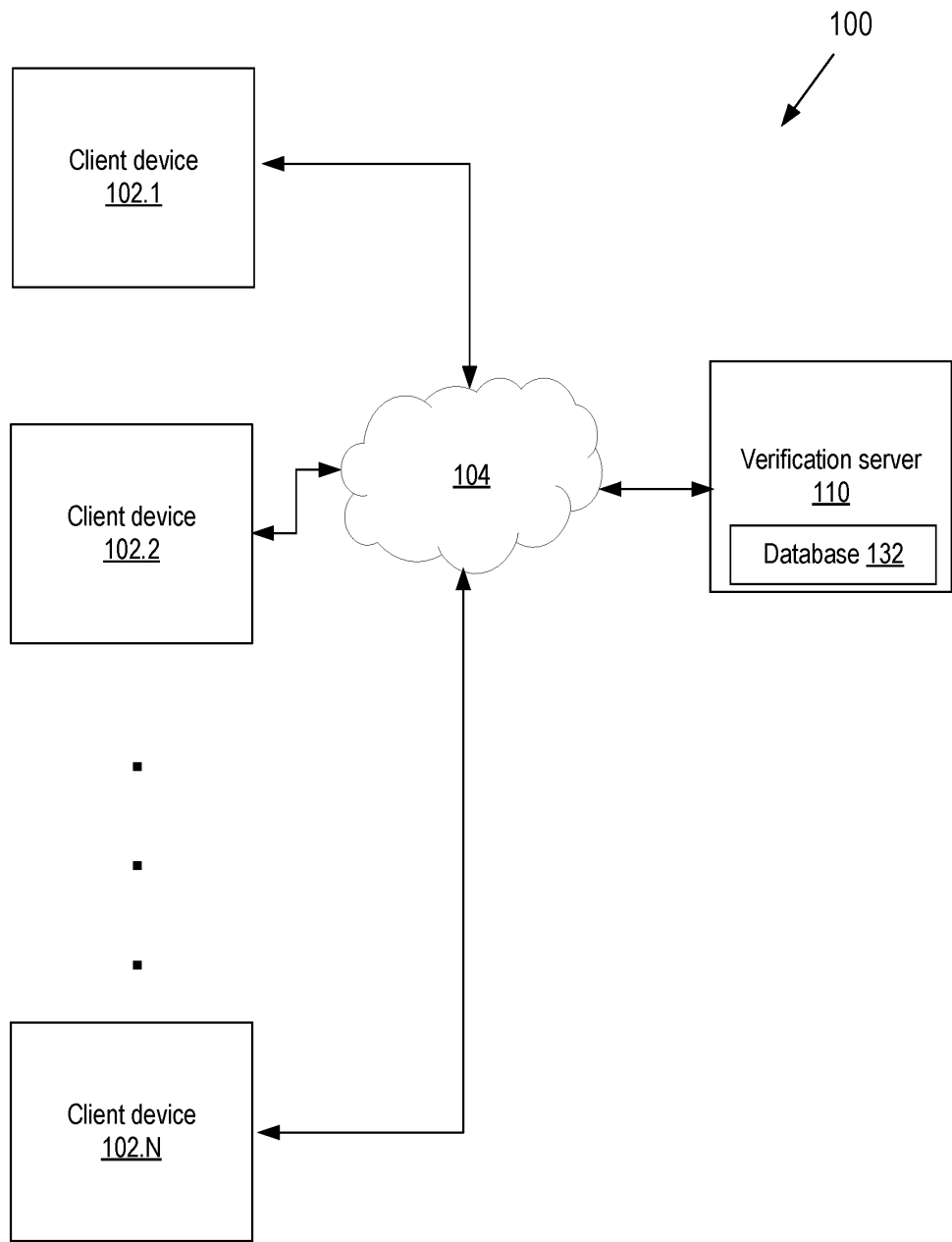


Figure 1

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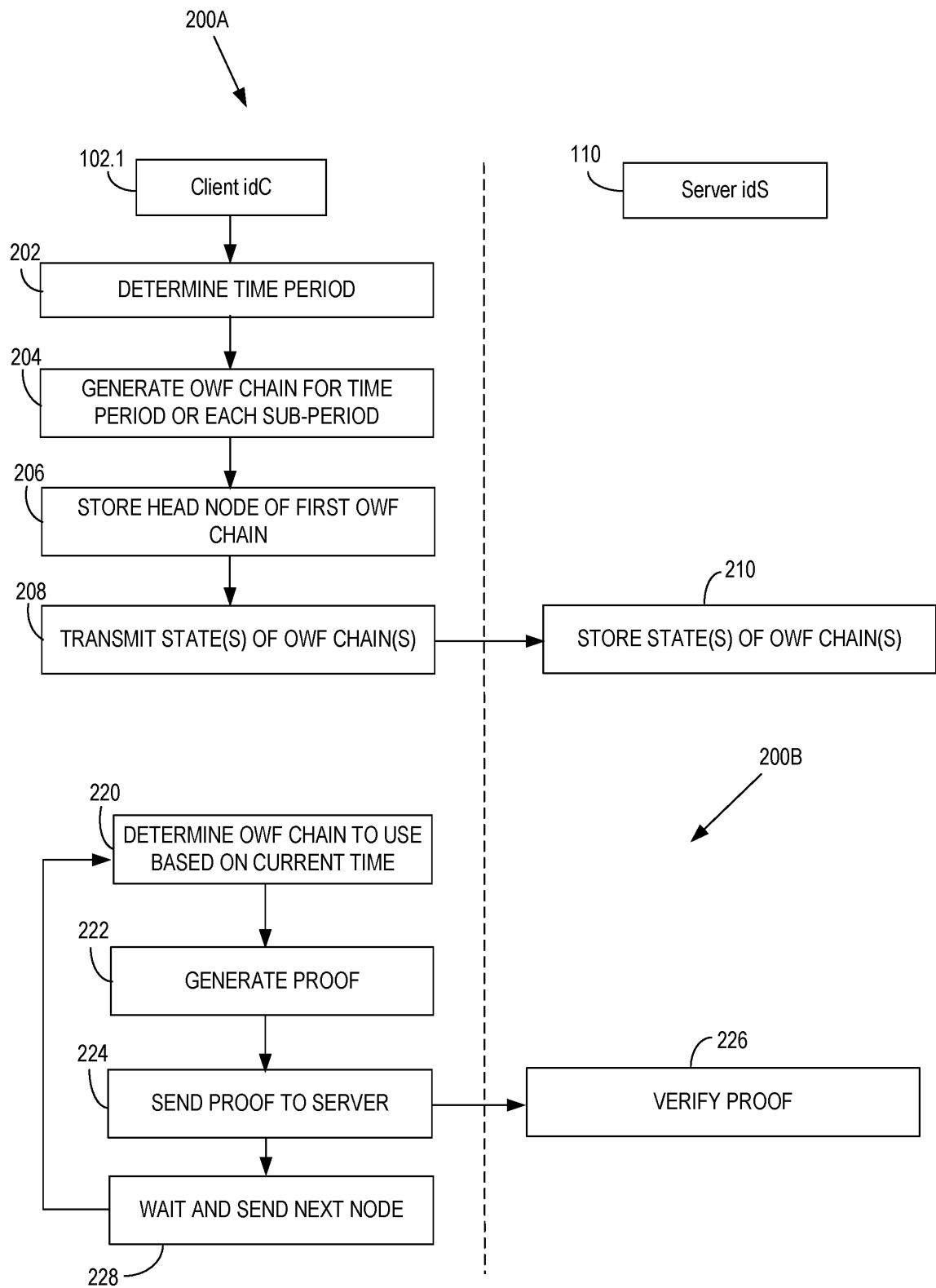


Figure 2

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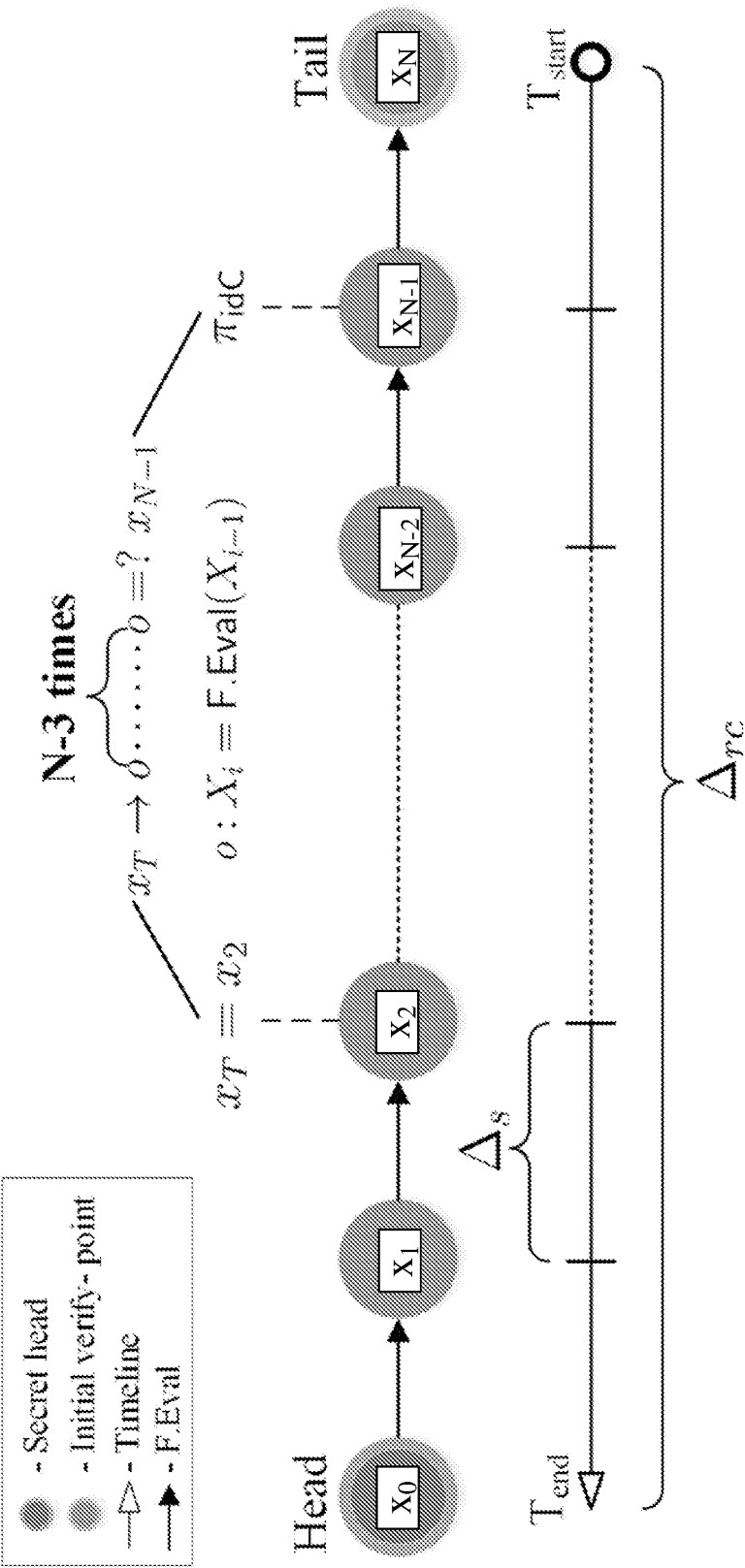


Figure 3

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$\Pi_{\text{OWF}}.\text{Setup}(1^\kappa, \rho_{\text{idC}}, T_{\text{start}}, \Delta_{rc}, T_{\text{att}}, \emptyset):$
 $pms_{\text{idC}} \xleftarrow{\$} \text{F.Setup}(1^\kappa)$
 $N := \lfloor \frac{\Delta_{rc}}{\Delta_s} \rfloor$
 $x_0 := \rho_{\text{idC}}$
 For $i \in [N]$:
 $\quad x_i := \text{F.Eval}(x_{i-1})$
 $\pi_{\text{idC}} := x_N$
 $T_{\text{ack}}^{\text{idC}} := T_{\text{ver}} := T_{\text{start}}$
 $T_{\text{end}} := T_{\text{start}} + \Delta_{rc}$
 $\text{st}_{\text{idC}} = (\rho_{\text{idC}}, T_{\text{end}}, pms_{\text{idC}})$
 $\text{st}_{\text{idS}, \text{idC}} = (\pi_{\text{idC}}, T_{\text{ack}}^{\text{idC}}, T_{\text{ver}}, pms_{\text{idC}})$
 Return $(\text{st}_{\text{idC}}, \text{st}_{\text{idS}, \text{idC}})$

Figure 4A

$\Pi_{\text{OWF}}.\text{NextPf}(\text{st}_{\text{idC}}, T):$
 $x_0 := \rho_{\text{idC}}$
 $M := \frac{T_{\text{end}} - T}{\Delta_s}$
 For $i \in [M]$:
 $\quad x_i := \text{F.Eval}(x_{i-1})$
 $x_T := x_M$
 Return x_T

Figure 4B

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 $\Pi_{\text{OWF}}.\text{Verify}(\text{st}_{\text{idS}, \text{idC}}, x_T, T, T_{\text{ack}}^{\text{idC}});$ 
 $vr := 0$ 
if  $T - T_{\text{ack}}^{\text{idC}} > T_{\text{att}}$ 
  Return  $vr$ ;
 $Z := \frac{T - T_{\text{ver}}}{\Delta_s}$ 
 $x'_0 := x_T$ 
For  $i \in [Z]$ :
   $x'_i := \text{F.Eval}(x'_{i-1})$ 
  if  $x_Z = \pi_{\text{idC}}$ :
     $vr := 1$ 
     $\pi_{\text{idC}} := x'_0$ 
     $T_{\text{ver}} := T$ 
     $T_{\text{ack}}^{\text{idC}} := T_{\text{ver}}$ 
Return  $vr$ 

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Figure 5

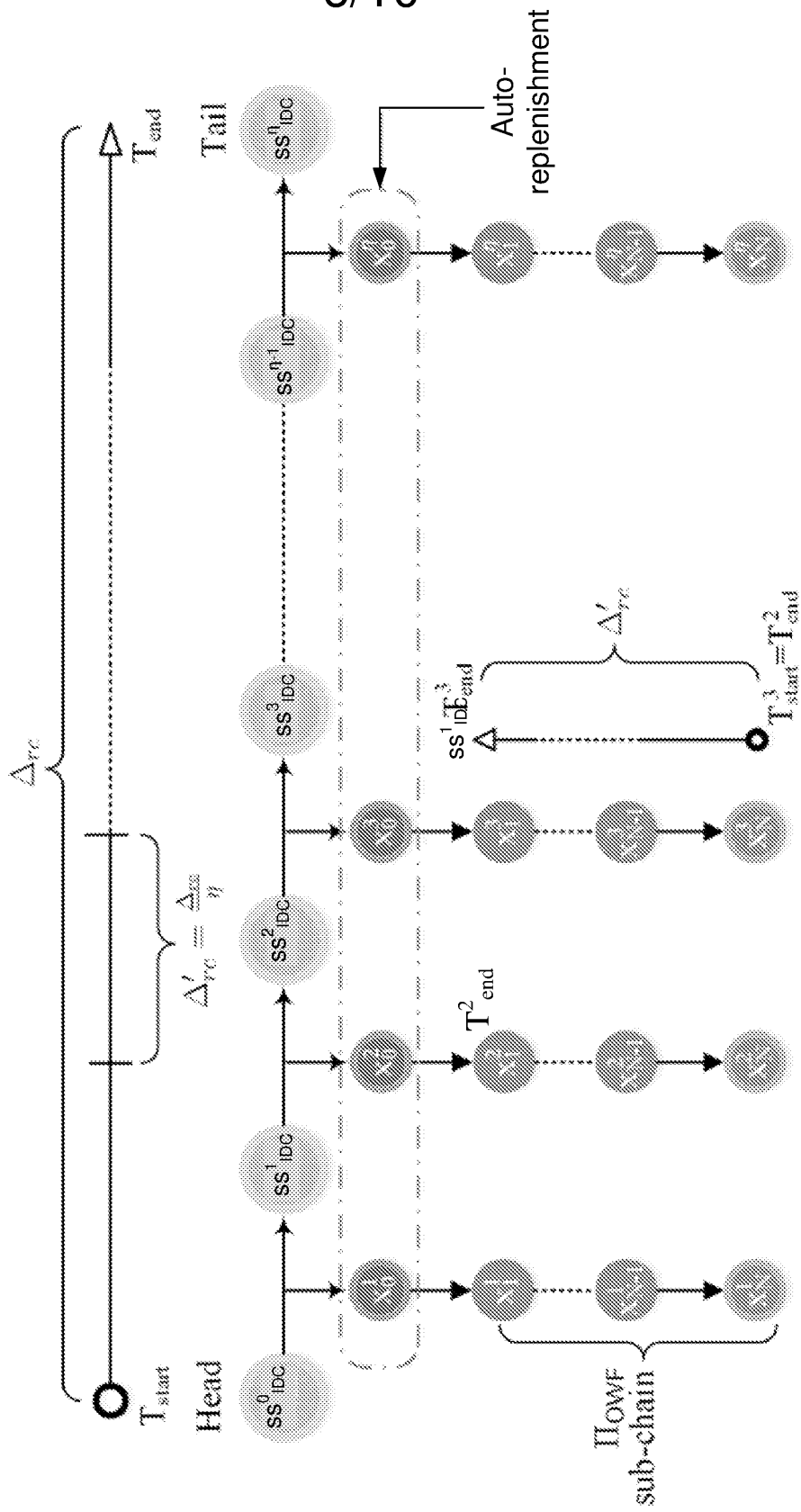


Figure 6

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$\Pi_{\text{OWF}}^{\text{PRG}}.\text{Setup}(1^\kappa, \rho_{\text{idC}}, T_{\text{start}}, \Delta_{rc}, T_{\text{att}}, \eta);$
 $pms_G \xleftarrow{\$} G.\text{Setup}(1^\kappa)$
 $\Delta'_{rc} := \lfloor \frac{\Delta_{rc}}{\eta} \rfloor$
 $ss_{\text{idC}}^0 = \rho_{\text{idC}}$
 $T_{\text{ack}}^{\text{idC}} := T_{\text{end}}^1 := T_{\text{start}}$
 For $i \in [\eta]$:
 $ss_{\text{idC}}^i || \rho_{\text{idC}}^i := G.\text{Gen}(ss_{\text{idC}}^{i-1})$
 $(st_{\text{idC}}^i, st_{\text{idS, idC}}^i) := \Pi_{\text{OWF}}.\text{Setup}(1^\kappa, \rho_{\text{idC}}^i, T_{\text{end}}^{i-1}, \Delta'_{rc}, T_{\text{att}}, \emptyset)$
 $st_{\text{idC}}^i = (\rho_{\text{idC}}^i, T_{\text{end}}^i, pms_G)$
 $st_{\text{idS, idC}}^i = (\pi_{\text{idC}}^i, T_{\text{ver}}^i, pms_G)$
 $u := 1$
 $st_{\text{idC}} = (ss_{\text{idC}}^u, \rho_{\text{idC}}^u, \{T_{\text{end}}^i\}_{0 \leq i \leq \eta}, \eta, u, pms_G)$
 $st_{\text{idS, idC}} = (\{st_{\text{idS, idC}}^i\}_{i \in [\eta]}, \{T_{\text{end}}^i\}_{0 \leq i \leq \eta}, T_{\text{ack}}^{\text{idC}}, \eta)$
 Return $(st_{\text{idC}}, st_{\text{idS, idC}})$

Figure 7

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 $\Pi_{\text{OWF}}^{\text{PRG}}.\text{NextPf}(\text{st}_{\text{idC}}, T):$ 
 $i := 0$ 
For  $j \in [\eta]$ :
  If  $T_{\text{end}}^{j-1} < T \leq T_{\text{end}}^j$  then
     $i := j$ 
If  $i = 0$  then
  Return  $\perp$ 
While  $u < i$ :
   $u := u + 1$ 
   $ss_{\text{idC}}^u || \rho_{\text{idC}}^u := \text{G.Gen}(ss_{\text{idC}}^{u-1})$ 
  Delete  $(ss_{\text{idC}}^{u-1}, \rho_{\text{idC}}^{u-1})$ 
Return  $\Pi_{\text{OWF}}.\text{NextPf}(\text{st}_{\text{idC}}^i, T)$ 

```

Figure 8A

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 $\Pi_{\text{OWF}}^{\text{PRG}}.\text{Verify}(\text{st}_{\text{idS}, \text{idC}}, x_T, T, T_{\text{ack}}^{\text{idC}}):$ 
 $i := 0$ 
For  $j \in [\eta]$ :
  If  $T_{\text{end}}^{j-1} < T \leq T_{\text{end}}^j$  then
     $i := j$ 
Return  $\Pi_{\text{OWF}}.\text{Verify}(\text{st}_{\text{idS}, \text{idC}}^i, x_T, T, T_{\text{ack}}^{\text{idC}})$ 

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Figure 8B

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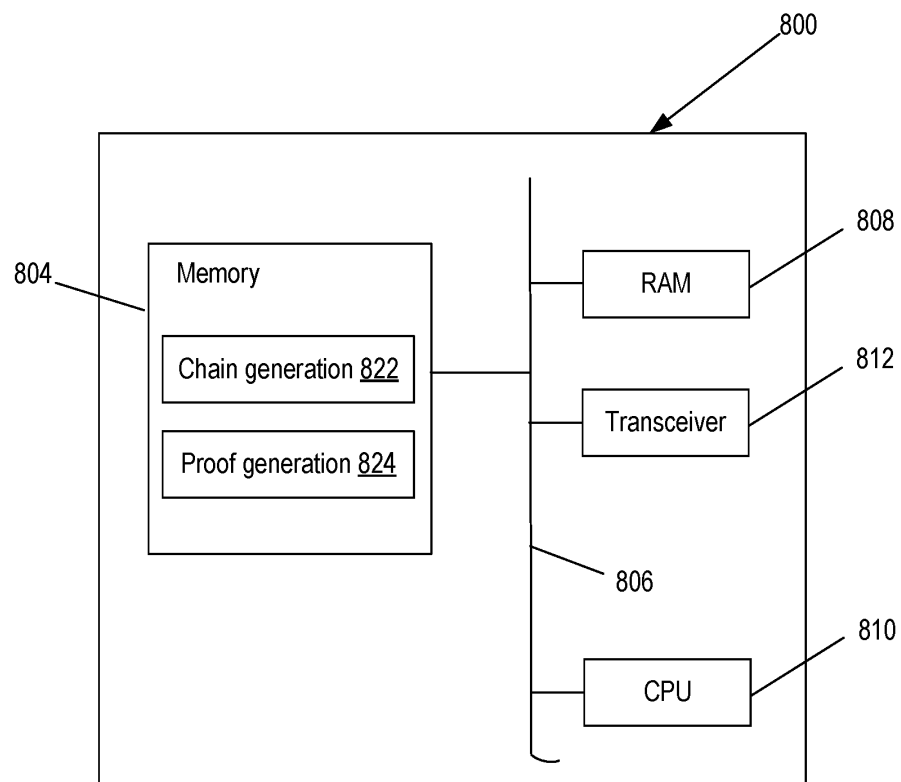


Figure 9

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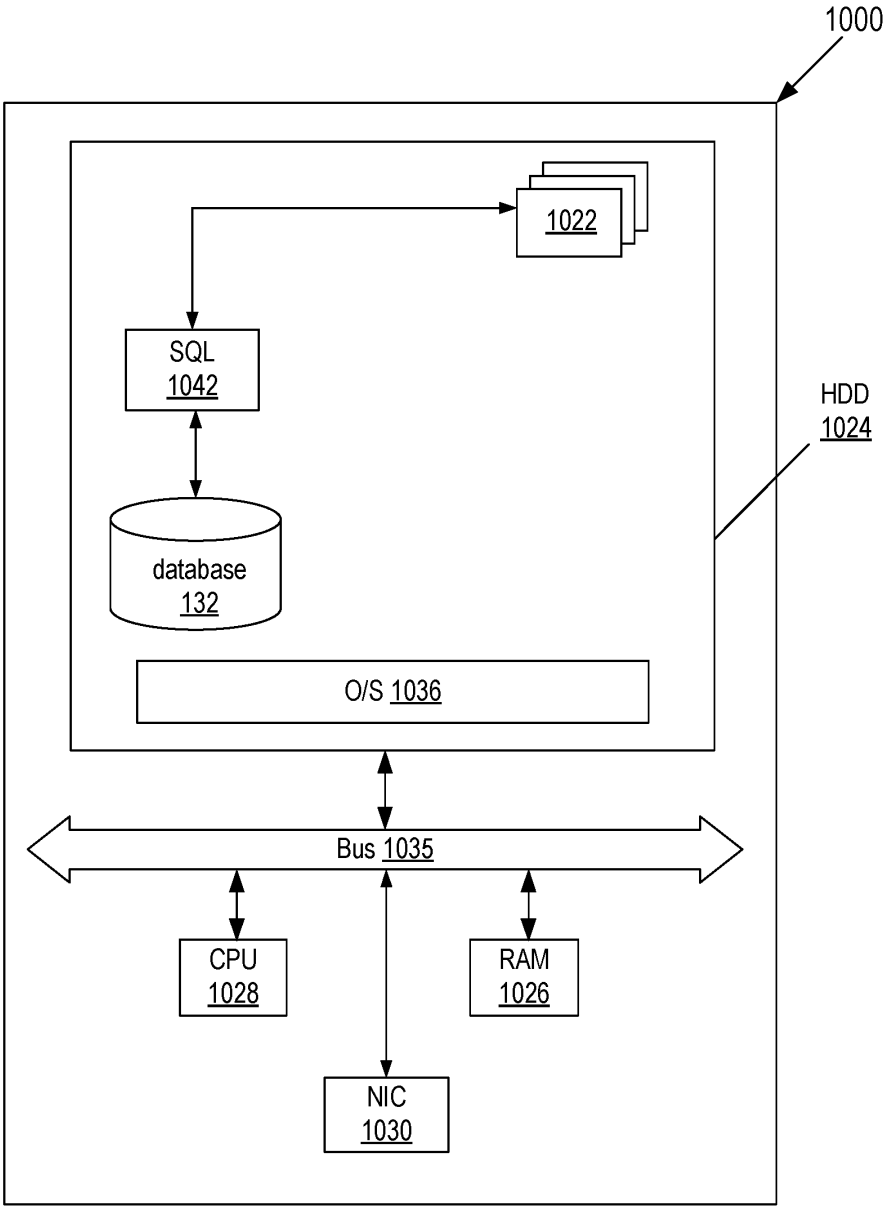


Figure 10