

$$D_{20,20} = \begin{pmatrix} 0 & 5 & 6 & 8 & 9 & 11 & 11 & 10 & 10 & 9 & 8 & 10 & 11 & 12 & 16 & 18 & 20 & 20 & 18 & 20 \\ 5 & 0 & 1 & 3 & 4 & 6 & 6 & 5 & 7 & 8 & 9 & 11 & 12 & 13 & 11 & 13 & 15 & 15 & 13 & 15 \\ 6 & 1 & 0 & 2 & 3 & 5 & 5 & 6 & 8 & 9 & 10 & 12 & 13 & 14 & 10 & 12 & 14 & 14 & 12 & 14 \\ 8 & 3 & 2 & 0 & 1 & 3 & 5 & 6 & 8 & 9 & 10 & 12 & 13 & 14 & 10 & 12 & 14 & 12 & 10 & 12 \\ 9 & 4 & 3 & 1 & 0 & 2 & 4 & 5 & 7 & 8 & 9 & 11 & 12 & 13 & 9 & 11 & 13 & 11 & 9 & 11 \\ 11 & 6 & 5 & 3 & 2 & 0 & 2 & 3 & 5 & 6 & 7 & 9 & 10 & 11 & 7 & 9 & 11 & 9 & 7 & 9 \\ 11 & 6 & 5 & 5 & 4 & 2 & 0 & 1 & 3 & 4 & 5 & 7 & 8 & 9 & 5 & 7 & 9 & 9 & 7 & 9 \\ 10 & 5 & 6 & 6 & 5 & 3 & 1 & 0 & 2 & 3 & 4 & 6 & 7 & 8 & 6 & 8 & 10 & 10 & 8 & 10 \\ 10 & 7 & 8 & 8 & 7 & 5 & 3 & 2 & 0 & 1 & 2 & 4 & 5 & 6 & 6 & 8 & 10 & 10 & 8 & 10 \\ 9 & 8 & 9 & 9 & 8 & 6 & 4 & 3 & 1 & 0 & 1 & 3 & 4 & 5 & 7 & 9 & 11 & 11 & 9 & 11 \\ 8 & 9 & 10 & 10 & 9 & 7 & 5 & 4 & 2 & 1 & 0 & 2 & 3 & 4 & 8 & 10 & 12 & 12 & 10 & 12 \\ 10 & 11 & 12 & 12 & 11 & 9 & 7 & 6 & 4 & 3 & 2 & 0 & 1 & 2 & 6 & 8 & 10 & 10 & 8 & 10 \\ 11 & 12 & 13 & 13 & 12 & 10 & 8 & 7 & 5 & 4 & 3 & 1 & 0 & 1 & 5 & 7 & 9 & 9 & 7 & 9 \\ 12 & 13 & 14 & 14 & 13 & 11 & 9 & 8 & 6 & 5 & 4 & 2 & 1 & 0 & 4 & 6 & 8 & 8 & 6 & 8 \\ 16 & 11 & 10 & 10 & 9 & 7 & 5 & 6 & 6 & 7 & 8 & 6 & 5 & 4 & 0 & 2 & 4 & 4 & 2 & 4 \\ 18 & 13 & 12 & 12 & 11 & 9 & 7 & 8 & 8 & 9 & 10 & 8 & 7 & 6 & 2 & 0 & 2 & 2 & 2 & 2 \\ 20 & 15 & 14 & 14 & 13 & 11 & 9 & 10 & 10 & 11 & 12 & 10 & 9 & 8 & 4 & 2 & 0 & 2 & 4 & 4 \\ 20 & 15 & 14 & 12 & 11 & 9 & 9 & 10 & 10 & 11 & 12 & 10 & 9 & 8 & 4 & 2 & 2 & 0 & 2 & 2 \\ 18 & 13 & 12 & 10 & 9 & 7 & 7 & 8 & 8 & 9 & 10 & 8 & 7 & 6 & 2 & 2 & 4 & 2 & 0 & 2 \\ 20 & 15 & 14 & 12 & 11 & 9 & 9 & 10 & 10 & 11 & 12 & 10 & 9 & 8 & 4 & 2 & 4 & 2 & 2 & 0 \end{pmatrix} \quad (5)$$

Operating in P system with DBSCAN clustering algorithm, we can obtain the computational process of P system. It is shown in Table 1- 4. Particularly, some repeated steps in the process are omitted.

Table 1 the clustering process in P system

	<i>Step0(initial state)</i>	<i>Step1</i>	<i>Step2</i>
<i>Mem0</i>	λ	λ	λ
<i>Mem1</i>	$a_1, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{1,1}^0, d_{1,2}^5, \dots, d_{1,19}^{18}, d_{1,20}^{20}(r_1)$	$B_1, \eta_1^1, \sigma^{19}(r_2)$
<i>Mem2</i>	$a_2, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{2,1}^5, d_{2,2}^0, \dots, d_{2,13}^{13}, d_{2,20}^{15}(r_1)$	$B_2, B_3, B_4, \eta_2^3, \sigma^{17}(r_2)$
<i>Mem3</i>	$a_3, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{3,1}^6, d_{3,2}^1, \dots, d_{3,19}^{12}, d_{3,20}^{14}(r_1)$	$B_2, B_3, B_4, B_5, \eta_3^4, \sigma^{16}(r_2)$
<i>Mem4</i>	$a_4, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{4,1}^8, d_{4,2}^3, \dots, d_{4,19}^{10}, d_{4,20}^{12}(r_1)$	$B_2, B_3, B_4, B_5, B_6, \eta_4^5, \sigma^{15}(r_2)$
<i>Mem5</i>	$a_5, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{5,1}^9, d_{5,2}^4, \dots, d_{5,19}^9, d_{5,20}^{11}(r_1)$	$B_3, B_4, B_5, B_6, \eta_5^4, \sigma^{16}(r_2)$
<i>Mem6</i>	$a_6, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{6,1}^{11}, d_{6,2}^6, \dots, d_{6,19}^7, d_{6,20}^9(r_1)$	$B_4, B_5, B_6, B_7, B_8, \eta_6^5, \sigma^{15}(r_2)$
<i>Mem7</i>	$a_7, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{7,1}^{11}, d_{7,2}^6, \dots, d_{7,19}^7, d_{7,20}^9(r_1)$	$B_6, B_7, B_8, B_9, \eta_7^4, \sigma^{16}(r_2)$
<i>Mem8</i>	$a_8, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{8,1}^{10}, d_{8,2}^5, \dots, d_{8,19}^8, d_{8,20}^{10}(r_1)$	$B_6, B_7, B_8, B_9, B_{10}, \eta_8^5, \sigma^{15}(r_2)$
<i>Mem9</i>	$a_9, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{9,1}^{10}, d_{9,2}^7, \dots, d_{9,19}^8, d_{9,20}^{10}(r_1)$	$B_7, B_8, B_9, B_{10}, B_{11}, \eta_9^5, \sigma^{15}(r_2)$
<i>Mem10</i>	$a_{10}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{10,1}^9, d_{10,2}^8, \dots, d_{10,19}^9, d_{10,20}^{11}(r_1)$	$B_8, B_9, B_{10}, B_{11}, B_{12}, \eta_{10}^5, \sigma^{15}(r_2)$
<i>Mem11</i>	$a_{11}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{11,1}^8, d_{11,2}^9, \dots, d_{11,19}^{10}, d_{11,20}^{12}(r_1)$	$B_9, B_{10}, B_{11}, B_{12}, \eta_{11}^4, \sigma^{16}(r_2)$
<i>Mem12</i>	$a_{12}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{12,1}^{10}, d_{12,2}^{11}, \dots, d_{12,19}^8, d_{12,20}^{10}(r_1)$	$B_{10}, B_{11}, B_{12}, B_{13}, B_{14}, \eta_{12}^5, \sigma^{15}(r_2)$
<i>Mem13</i>	$a_{13}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{13,1}^{11}, d_{13,2}^{12}, \dots, d_{13,19}^7, d_{13,20}^9(r_1)$	$B_{11}, B_{12}, B_{13}, B_{14}, \eta_{13}^4, \sigma^{16}(r_2)$
<i>Mem14</i>	$a_{14}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{14,1}^{12}, d_{14,2}^{13}, \dots, d_{14,19}^6, d_{14,20}^8(r_1)$	$B_{12}, B_{13}, B_{14}, \eta_{14}^3, \sigma^{17}(r_2)$
<i>Mem15</i>	$a_{15}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{15,1}^{16}, d_{15,2}^{11}, \dots, d_{15,19}^2, d_{15,20}^4(r_1)$	$B_{15}, B_{16}, B_{19}, \eta_{15}^3, \sigma^{17}(r_2)$
<i>Mem16</i>	$a_{16}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{16,1}^{18}, d_{16,2}^{13}, \dots, d_{16,19}^2, d_{16,20}^2(r_1)$	$B_{15}, B_{16}, B_{17}, B_{18}, B_{19}, B_{20}, \eta_{16}^6, \sigma^{14}(r_2)$
<i>Mem17</i>	$a_{17}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{17,1}^{20}, d_{17,2}^{15}, \dots, d_{17,19}^4, d_{17,20}^4(r_1)$	$B_{16}, B_{17}, B_{18}, \eta_{17}^3, \sigma^{17}(r_2)$
<i>Mem18</i>	$a_{18}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{18,1}^{20}, d_{18,2}^{15}, \dots, d_{18,19}^2, d_{18,20}^2(r_1)$	$B_{16}, B_{17}, B_{18}, B_{19}, B_{20}, \eta_{18}^5, \sigma^{15}(r_2)$
<i>Mem19</i>	$a_{19}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{19,1}^{18}, d_{19,2}^{13}, \dots, d_{19,19}^0, d_{19,20}^2(r_1)$	$B_{15}, B_{16}, B_{18}, B_{19}, B_{20}, \eta_{19}^5, \sigma^{15}(r_2)$
<i>Mem20</i>	$a_{20}, b_1, b_2, \dots, b_{19}, b_{20}$	$d_{20,1}^{20}, d_{20,2}^{15}, \dots, d_{20,19}^2, d_{20,20}^0(r_1)$	$B_{16}, B_{18}, B_{19}, B_{20}, \eta_{20}^4, \sigma^{16}(r_2)$

Table 1(continued) the clustering process in P system

	<i>Step3</i>	<i>Step4</i>
<i>Mem0</i>	λ	λ
<i>Mem1</i>	$N_1, \eta_1^1, \sigma^{19}(r_3)$	$N_1, \eta_1^1, \sigma^{19}(r_3)$
<i>Mem2</i>	$B_2, B_3, B_4, \gamma_2^3, \eta_2^3, \sigma^{17}(r_3)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^3, \sigma^{17}(r_3)$
<i>Mem3</i>	$B_2, B_3, B_4, B_5, \gamma_3^4, \eta_3^4, \sigma^{16}(r_3)$	$c_{3a_2}, c_{3a_3}, c_{3a_4}, c_{3a_5}, \eta_3^4, \sigma^{16}(r_3)$
<i>Mem4</i>	$B_2, B_3, B_4, B_5, B_6, \gamma_4^5, \eta_4^5, \sigma^{15}(r_3)$	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^5, \sigma^{15}(r_3)$
<i>Mem5</i>	$B_3, B_4, B_5, B_6, \gamma_5^4, \eta_5^4, \sigma^{16}(r_3)$	$c_{5a_3}, c_{5a_4}, c_{5a_5}, c_{5a_6}, \eta_5^4, \sigma^{16}(r_3)$
<i>Mem6</i>	$B_4, B_5, B_6, B_7, B_8, \gamma_6^5, \eta_6^5, \sigma^{15}(r_3)$	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^5, \sigma^{15}(r_3)$
<i>Mem7</i>	$B_6, B_7, B_8, B_9, \gamma_7^4, \eta_7^4, \sigma^{16}(r_3)$	$c_{7a_6}, c_{7a_7}, c_{7a_8}, c_{7a_9}, \eta_7^4, \sigma^{16}(r_3)$
<i>Mem8</i>	$B_6, B_7, B_8, B_9, B_{10}, \gamma_8^5, \eta_8^5, \sigma^{15}(r_3)$	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^5, \sigma^{15}(r_3)$
<i>Mem9</i>	$B_7, B_8, B_9, B_{10}, B_{11}, \gamma_9^5, \eta_9^5, \sigma^{15}(r_3)$	$c_{9a_7}, c_{9a_8}, c_{9a_9}, c_{9a_{10}}, c_{9a_{11}}, \eta_9^5, \sigma^{15}(r_3)$
<i>Mem10</i>	$B_8, B_9, B_{10}, B_{11}, B_{12}, \gamma_{10}^5, \eta_{10}^5, \sigma^{15}(r_3)$	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^5, \sigma^{15}(r_3)$
<i>Mem11</i>	$B_9, B_{10}, B_{11}, B_{12}, \gamma_{11}^4, \eta_{11}^4, \sigma^{16}(r_3)$	$c_{11a_9}, c_{11a_{10}}, c_{11a_{11}}, c_{11a_{12}}, \eta_{11}^4, \sigma^{16}(r_3)$
<i>Mem12</i>	$B_{10}, B_{11}, B_{12}, B_{13}, B_{14}, \gamma_{12}^5, \eta_{12}^5, \sigma^{15}(r_3)$	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^5, \sigma^{15}(r_3)$
<i>Mem13</i>	$B_{11}, B_{12}, B_{13}, B_{14}, \gamma_{13}^4, \eta_{13}^4, \sigma^{16}(r_3)$	$c_{13a_{11}}, c_{13a_{12}}, c_{13a_{13}}, c_{13a_{14}}, \eta_{13}^4, \sigma^{16}(r_3)$
<i>Mem14</i>	$B_{12}, B_{13}, B_{14}, \gamma_{14}^3, \eta_{14}^3, \sigma^{17}(r_3)$	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3, \sigma^{17}(r_3)$
<i>Mem15</i>	$B_{15}, B_{16}, B_{19}, \gamma_{15}^3, \eta_{15}^3, \sigma^{17}(r_3)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^3, \sigma^{17}(r_3)$
<i>Mem16</i>	$B_{15}, B_{16}, B_{17}, B_{18}, B_{19}, B_{20}, \gamma_{16}^6, \eta_{16}^6, \sigma^{14}(r_3)$	$c_{16a_{15}}, c_{16a_{16}}, c_{16a_{17}}, c_{16a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^6, \sigma^{14}(r_3)$
<i>Mem17</i>	$B_{16}, B_{17}, B_{18}, \gamma_{17}^3, \eta_{17}^3, \sigma^{17}(r_3)$	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^3, \sigma^{17}(r_3)$
<i>Mem18</i>	$B_{16}, B_{17}, B_{18}, B_{19}, B_{20}, \gamma_{18}^5, \eta_{18}^5, \sigma^{15}(r_3)$	$c_{18a_{16}}, c_{18a_{17}}, c_{18a_{18}}, c_{18a_{19}}, c_{18a_{20}}, \eta_{18}^5, \sigma^{15}(r_3)$
<i>Mem19</i>	$B_{15}, B_{16}, B_{18}, B_{19}, B_{20}, \gamma_{19}^5, \eta_{19}^5, \sigma^{15}(r_3)$	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^5, \sigma^{15}(r_3)$
<i>Mem20</i>	$B_{16}, B_{18}, B_{19}, B_{20}, \gamma_{20}^4, \eta_{20}^4, \sigma^{16}(r_3)$	$c_{20a_{16}}, c_{20a_{18}}, c_{20a_{19}}, c_{20a_{20}}, \eta_{20}^4, \sigma^{16}(r_3)$

Table 1(continued) the clustering process in P system

	<i>Step5</i>	<i>Step6</i>
<i>Mem0</i>	λ	λ
<i>Mem1</i>	$N_1, \eta_1^1(r_4)$	$N_1, \eta_1^1(r_4)$
<i>Mem2</i>	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^3(r_4)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^4(r_5)$
<i>Mem3</i>	$c_{3a_2}, c_{3a_3}, c_{3a_4}, c_{3a_5}, \eta_3^4(r_4)$	$c_{3a_2}, c_{2a_3}, c_{3a_4}, c_{3a_5}, \eta_3^3(r_5)$
<i>Mem4</i>	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^5(r_4)$	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^6(r_5)$
<i>Mem5</i>	$c_{5a_3}, c_{5a_4}, c_{5a_5}, c_{5a_6}, \eta_5^4(r_4)$	$c_{4a_3}, c_{5a_4}, c_{5a_5}, c_{5a_6}, \eta_5^3(r_5)$
<i>Mem6</i>	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^5(r_4)$	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^6(r_5)$
<i>Mem7</i>	$c_{7a_6}, c_{7a_7}, c_{7a_8}, c_{7a_9}, \eta_7^4(r_4)$	$c_{7a_6}, c_{6a_7}, c_{7a_8}, c_{7a_9}, \eta_7^3(r_5)$
<i>Mem8</i>	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^5(r_4)$	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^6(r_5)$
<i>Mem9</i>	$c_{9a_7}, c_{9a_8}, c_{9a_9}, c_{9a_{10}}, c_{9a_{11}}, \eta_9^5(r_4)$	$c_{8a_7}, c_{9a_8}, c_{9a_9}, c_{9a_{10}}, c_{9a_{11}}, \eta_9^4(r_5)$
<i>Mem10</i>	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^5(r_4)$	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^6(r_5)$

<i>Mem11</i>	$c_{11a_9}, c_{11a_{10}}, c_{11a_{11}}, c_{11a_{12}}, \eta_{11}^4(r_4)$	$c_{10a_9}, c_{11a_{10}}, c_{11a_{11}}, c_{11a_{12}}, \eta_{11}^3(r_5)$
<i>Mem12</i>	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^5(r_4)$	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^6(r_5)$
<i>Mem13</i>	$c_{13a_{11}}, c_{13a_{12}}, c_{13a_{13}}, c_{13a_{14}}, \eta_{13}^4(r_4)$	$c_{12a_{11}}, c_{13a_{12}}, c_{13a_{13}}, c_{13a_{14}}, \eta_{13}^3(r_5)$
<i>Mem14</i>	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3(r_4)$	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3(r_5)$
<i>Mem15</i>	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^3(r_4)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^4(r_5)$
<i>Mem16</i>	$c_{16a_{15}}, c_{16a_{16}}, c_{16a_{17}}, c_{16a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^6(r_4)$	$c_{16a_{15}}, c_{15a_{16}}, c_{16a_{17}}, c_{16a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^5(r_5)$
<i>Mem17</i>	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^3(r_4)$	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^4(r_5)$
<i>Mem18</i>	$c_{18a_{16}}, c_{18a_{17}}, c_{18a_{18}}, c_{18a_{19}}, c_{18a_{20}}, \eta_{18}^5(r_4)$	$c_{17a_{16}}, c_{18a_{17}}, c_{18a_{18}}, c_{18a_{19}}, c_{18a_{20}}, \eta_{18}^4(r_5)$
<i>Mem19</i>	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^5(r_4)$	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^6(r_5)$
<i>Mem20</i>	$c_{20a_{16}}, c_{20a_{18}}, c_{20a_{19}}, c_{20a_{20}}, \eta_{20}^4(r_4)$	$c_{19a_{16}}, c_{20a_{18}}, c_{20a_{19}}, c_{20a_{20}}, \eta_{20}^3(r_5)$

Table 1(continued) the clustering process in P system

	<i>Step7</i>	<i>Step8</i>
<i>Mem0</i>	λ	λ
<i>Mem1</i>	$N_1, \eta_1^1(r_4)$	$N_1, \eta_1^1(r_4)$
<i>Mem2</i>	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^5(r_5)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^6(r_5)$
<i>Mem3</i>	$c_{3a_2}, c_{2a_3}, c_{2a_4}, c_{3a_5}, \eta_3^2(r_5)$	$c_{3a_2}, c_{2a_3}, c_{2a_4}, c_{2a_5}, \eta_3^1(r_5)$
<i>Mem4</i>	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^7(r_5)$	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^8(r_5)$
<i>Mem5</i>	$c_{4a_3}, c_{5a_4}, c_{4a_5}, c_{5a_6}, \eta_5^2(r_5)$	$c_{4a_3}, c_{5a_4}, c_{4a_5}, c_{4a_6}, \eta_5^1(r_5)$
<i>Mem6</i>	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^7(r_5)$	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^8(r_5)$
<i>Mem7</i>	$c_{7a_6}, c_{6a_7}, c_{6a_8}, c_{7a_9}, \eta_7^2(r_5)$	$c_{7a_6}, c_{6a_7}, c_{6a_8}, c_{6a_9}, \eta_7^1(r_5)$
<i>Mem8</i>	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^7(r_5)$	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^8(r_5)$
<i>Mem9</i>	$c_{8a_7}, c_{9a_8}, c_{8a_9}, c_{9a_{10}}, c_{9a_{11}}, \eta_9^3(r_5)$	$c_{8a_7}, c_{9a_8}, c_{8a_9}, c_{8a_{10}}, c_{9a_{11}}, \eta_9^2(r_5)$
<i>Mem10</i>	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^7(r_5)$	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^8(r_5)$
<i>Mem11</i>	$c_{10a_9}, c_{11a_{10}}, c_{10a_{11}}, c_{11a_{12}}, \eta_{11}^2(r_5)$	$c_{10a_9}, c_{11a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{11}^1(r_5)$
<i>Mem12</i>	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^7(r_5)$	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^8(r_5)$
<i>Mem13</i>	$c_{12a_{11}}, c_{13a_{12}}, c_{12a_{13}}, c_{13a_{14}}, \eta_{13}^2(r_5)$	$c_{12a_{11}}, c_{13a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{13}^1(r_5)$
<i>Mem14</i>	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3$	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3$
<i>Mem15</i>	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^5(r_5)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^6(r_5)$
<i>Mem16</i>	$c_{16a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{16a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^4(r_5)$	$c_{16a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{15a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^3(r_5)$
<i>Mem17</i>	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^5(r_5)$	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^6(r_5)$
<i>Mem18</i>	$c_{17a_{16}}, c_{18a_{17}}, c_{17a_{18}}, c_{18a_{19}}, c_{18a_{20}}, \eta_{18}^3(r_5)$	$c_{17a_{16}}, c_{18a_{17}}, c_{17a_{18}}, c_{17a_{19}}, c_{18a_{20}}, \eta_{18}^2(r_5)$
<i>Mem19</i>	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^7(r_5)$	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^8(r_5)$
<i>Mem20</i>	$c_{19a_{16}}, c_{19a_{18}}, c_{20a_{19}}, c_{20a_{20}}, \eta_{20}^2(r_5)$	$c_{19a_{16}}, c_{19a_{18}}, c_{20a_{19}}, c_{19a_{20}}, \eta_{20}^1(r_5)$

Table 2 the clustering process in P system

	<i>Step9</i>	<i>Step10</i>
<i>Mem0</i>	λ	λ
<i>Mem1</i>	N_1, η_1^1	N_1, η_1^1
<i>Mem2</i>	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^6(r_5)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^6,$ $c_{3a_2}, c_{2a_3}, c_{2a_4}, c_{2a_5}, \eta_3^1(r_6)$
<i>Mem4</i>	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^8,$ $c_{4a_3}, c_{5a_4}, c_{4a_5}, c_{4a_6}, \eta_5^1(r_6)$	$c_{4a_2}, c_{4a_3}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^8,$ $c_{4a_2}, c_{5a_4}, c_{4a_5}, c_{4a_6}, \eta_5^1(r_6)$
<i>Mem6</i>	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^8,$ $c_{7a_6}, c_{6a_7}, c_{6a_8}, c_{6a_9}, \eta_7^1(r_6)$	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_7}, c_{6a_8}, \eta_6^8,$ $c_{7a_6}, c_{6a_7}, c_{6a_8}, c_{6a_9}, \eta_7^1(r_6)$
<i>Mem8</i>	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^8(r_5)$	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^9(r_5)$
<i>Mem9</i>	$c_{8a_7}, c_{9a_8}, c_{8a_9}, c_{8a_{10}}, c_{9a_{11}}, \eta_9^2(r_5)$	$c_{8a_6}, c_{9a_8}, c_{8a_9}, c_{8a_{10}}, c_{8a_{11}}, \eta_9^1(r_5)$
<i>Mem10</i>	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^8,$ $c_{10a_9}, c_{11a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{11}^1(r_6)$	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^8,$ $c_{10a_9}, c_{11a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{11}^1(r_6)$
<i>Mem12</i>	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^8,$ $c_{12a_{11}}, c_{13a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{13}^1(r_6)$	$c_{12a_{10}}, c_{12a_{11}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^8,$ $c_{12a_{10}}, c_{13a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{13}^1(r_6)$
<i>Mem14</i>	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3$	$c_{14a_{12}}, c_{14a_{13}}, c_{14a_{14}}, \eta_{14}^3$
<i>Mem15</i>	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^6(r_5)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^7(r_5)$
<i>Mem16</i>	$c_{16a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{15a_{18}}, c_{16a_{19}}, c_{16a_{20}}, \eta_{16}^3(r_5)$	$c_{16a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{15a_{18}}, c_{15a_{19}}, c_{16a_{20}}, \eta_{16}^2(r_5)$
<i>Mem17</i>	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^6(r_5)$	$c_{17a_{16}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^7(r_5)$
<i>Mem18</i>	$c_{17a_{16}}, c_{18a_{17}}, c_{17a_{18}}, c_{17a_{19}}, c_{18a_{20}}, \eta_{18}^2(r_5)$	$c_{17a_{16}}, c_{18a_{17}}, c_{17a_{18}}, c_{17a_{19}}, c_{17a_{20}}, \eta_{18}^1(r_5)$
<i>Mem19</i>	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^8,$ $c_{19a_{16}}, c_{19a_{18}}, c_{20a_{19}}, c_{19a_{20}}, \eta_{20}^1(r_5)$	$c_{19a_{15}}, c_{19a_{16}}, c_{19a_{18}}, c_{19a_{19}}, c_{19a_{20}}, \eta_{19}^8,$ $c_{19a_{16}}, c_{19a_{18}}, c_{20a_{19}}, c_{19a_{20}}, \eta_{20}^1(r_6)$

Table 3 the clustering process in P system

	<i>Step11</i>	<i>Step12</i>	...
<i>Mem0</i>	λ	λ	...
<i>Mem1</i>	N_1, η_1^1	N_1, η_1^1	...
<i>Mem2</i>	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^5, c_{2a_4}, c_{2a_5}(r_7)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_2^4, c_{2a_5}(r_7)$	...
<i>Mem4</i>	$c_{4a_2}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^7, c_{4a_2}, c_{4a_5}, c_{4a_6}(r_7)$	$c_{4a_2}, c_{4a_4}, c_{4a_5}, c_{4a_6}, \eta_4^6, c_{4a_5}, c_{4a_6}(r_7)$	...
<i>Mem6</i>	$c_{6a_4}, c_{6a_5}, c_{6a_6}, c_{6a_8}, \eta_6^7,$ $c_{6a_7}, c_{6a_8}, c_{6a_9}(r_7)$	$c_{6a_4}, c_{6a_5}, c_{6a_6}, \eta_6^6,$ $c_{6a_7}, c_{6a_8}, c_{6a_9}(r_7)$	...
<i>Mem8</i>	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_9}, c_{8a_{10}}, \eta_8^9$ $c_{8a_6}, c_{8a_9}, c_{8a_{10}}, c_{8a_{11}}(r_6)$	$c_{8a_6}, c_{8a_7}, c_{8a_8}, c_{8a_{10}}, \eta_8^8$ $c_{8a_6}, c_{8a_9}, c_{8a_{10}}, c_{8a_{11}}(r_6)$	...
<i>Mem10</i>	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^7,$ $c_{10a_{11}}, c_{10a_{12}}(r_7)$	$c_{10a_8}, c_{10a_9}, c_{10a_{10}}, c_{10a_{11}}, c_{10a_{12}}, \eta_{10}^6,$ $c_{10a_{12}}(r_7)$	...

<i>Mem12</i>	$c_{12a_{10}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^6,$ $c_{12a_{10}}, c_{12a_{14}}(r_7)$	$c_{12a_{10}}, c_{12a_{10}}, c_{12a_{12}}, c_{12a_{13}}, c_{12a_{14}}, \eta_{12}^5,$ $c_{12a_{14}}(r_7)$	...
<i>Mem14</i>	$c_{14a_{12}}, c_{14a_{12}}, c_{14a_{14}}, \eta_{14}^3$	$c_{14a_{12}}, c_{14a_{12}}, c_{14a_{14}}, \eta_{14}^3$	...
<i>Mem15</i>	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^8, c_{16a_{15}}, c_{15a_{16}},$ $c_{15a_{17}}, c_{15a_{18}}, c_{15a_{19}}, c_{15a_{20}}, \eta_{16}^1(r_6)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{19}}, \eta_{15}^7,$ $c_{15a_{17}}, c_{15a_{18}}, c_{15a_{19}}, c_{15a_{20}}(r_7)$	...
<i>Mem17</i>	$c_{17a_{15}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^6,$ $c_{17a_{18}}, c_{17a_{19}}, c_{17a_{20}}(r_7)$	$c_{17a_{15}}, c_{17a_{17}}, c_{17a_{18}}, \eta_{17}^5,$ $c_{17a_{19}}, c_{17a_{20}}(r_7)$	...
<i>Mem19</i>	$c_{19a_{15}}, c_{19a_{15}}, c_{19a_{17}}, c_{19a_{19}},$ $c_{19a_{20}}, \eta_{19}^6, c_{19a_{20}}(r_7)$	$c_{19a_{15}}, c_{19a_{15}}, c_{19a_{17}}, c_{19a_{19}},$ $c_{19a_{20}}, \eta_{19}^5(r_7)$	...

Table 4 the clustering process in P system

	<i>Step42</i>	<i>Step43</i>
<i>Mem0</i>	λ	$\eta_1^1, \eta_2^4, \eta_{15}^7(r_9)$
<i>Mem1</i>	N_1, η_1^1	$N_1(r_9)$
<i>Mem2</i>	$c_{2a_2}, c_{2a_3}, c_{2a_4}, \eta_{12}^{13}, c_{2a_5}, c_{2a_7}, c_{2a_8},$ $c_{2a_9}, c_{2a_{10}}, c_{2a_{12}}, c_{2a_{13}}, c_{2a_{14}}(r_7)$	$c_{2a_2}, c_{2a_3}, c_{2a_4}, c_{2a_5}, c_{2a_7}, c_{2a_8},$ $c_{2a_9}, c_{2a_{10}}, c_{2a_{12}}, c_{2a_{13}}, c_{2a_{14}}(r_9)$
<i>Mem15</i>	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{15a_{18}},$ $c_{15a_{19}}, c_{15a_{20}}, \eta_{15}^6(r_7)$	$c_{15a_{15}}, c_{15a_{16}}, c_{15a_{17}}, c_{15a_{18}},$ $c_{15a_{19}}, c_{15a_{20}}(r_9)$

In the process, Table 1 shows the rules execution in the membrane labeled i , which is used to determine if the object is core object. Table 2 and Table 3 show the membrane merge in the skin membrane. Two membranes are merged to produce a new cluster by collecting directly density-reachable objects from one core object. Table 4 shows the final membranes and objects remaining in the skin membrane.

Finally, the clustering of these 20 points in this P system is finished. The membrane structure of this P system is changed by the rules of active membranes. So the final structure of this P system is shown in Fig.8.

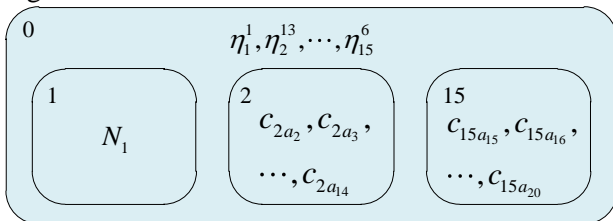


Fig.8 the final structure of this P system

According to the objects $\eta_1^1, \eta_2^4, \eta_{15}^7$ from the skin membrane, which represent three clusters, and the numbers of objects in these three clusters are separately 1, 13 and 6. Furthermore there are three

members which also indicate three clusters. The objects in each membrane represent the members in each cluster. The members are respectively a_1 and a_2, a_3, \dots, a_{14} and $a_{15}, a_{16}, \dots, a_{20}$. The result of the clustering is shown in Fig.9.

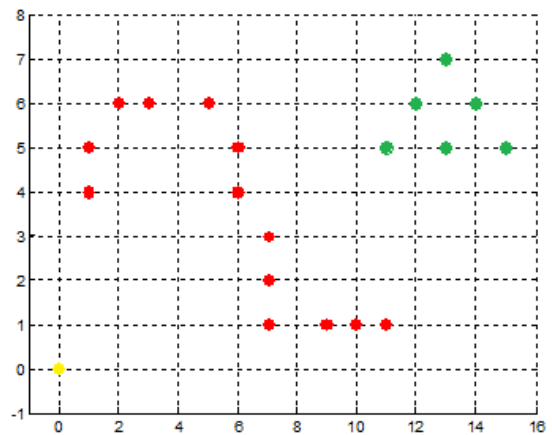


Fig.9 The result of DBSCAN clustering

5 Conclusion

The main feature of the P system with active membranes is that not only the objects evolve but also the membrane structure. Its characteristics of changing membrane structure make it more efficient

to solve clustering problems. This paper proposes a P system with active membranes to solve DBSCAN clustering problems. This new model of P system can improve the efficiency of the clustering process. Then the paper provides a general example to verify the feasibility and effectiveness of this P system. The result we obtained can be a strong proof of this P system. In recent years, with the development at full speed of membrane computing, the P system is used in the clustering problems more and more. But it is still in the initial stage and there is much more work for membrane computing to do. In future, we will continue to research how to using membrane computing techniques to realize more clustering algorithms and solve more practical problems with large database.

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