

$\varepsilon = 1.1$
 $\text{minPts} = 2$

$\varepsilon = 1.1$
 $\text{minPts} = 3$

$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

$\varepsilon = 4.1$
 $\text{minPts} = 4$

Data Mining Tutorial

Clusteranalyse – Teil II

Erich Schubert, Arthur Zimek

Ludwig-Maximilians-Universität München

2013-05-10 — KDD Übung

Sei:

- ▶ M_i = Modell (= Menge der Medoide) nach Iteration i .
- ▶ $TD(M_i)$ = Kosten von Modell M_i .

Aufgabe 3-1

Aufgabe 3-2

Beispiel

Berechnung

Aufgabe 3-3

$\varepsilon = 1.1$
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PAM konvergiert, wenn

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Es gibt $\binom{n}{k}$ mögliche Modelle,

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Es gibt $\binom{n}{k}$ mögliche Modelle, aber $\mathbb{N}$ Iterationen.

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$$\Rightarrow \exists_{t_1 < t_2} M_{t_1} = M_{t_2}$$

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$\varepsilon = 1.1$
 $\text{minPts} = 3$

$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

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- M_i = Modell (= Menge der Medoide) nach Iteration i .
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$$\Rightarrow TD(M_{t_1}) = TD(M_{t_2}) \quad \text{Widerspruch!}$$

$\epsilon = 1.1$
 $\text{minPts} = 2$

$\epsilon = 1.1$
 $\text{minPts} = 3$

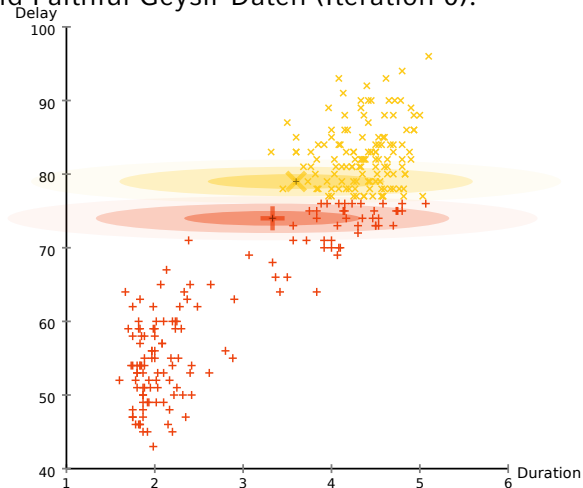
$\epsilon = 1.1$
 $\text{minPts} = 4$

$\epsilon = 2.1$
 $\text{minPts} = 4$

$\epsilon = 4.1$
 $\text{minPts} = 5$

$\epsilon = 4.1$
 $\text{minPts} = 4$

Old Faithful Geysir Daten (Iteration 0):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

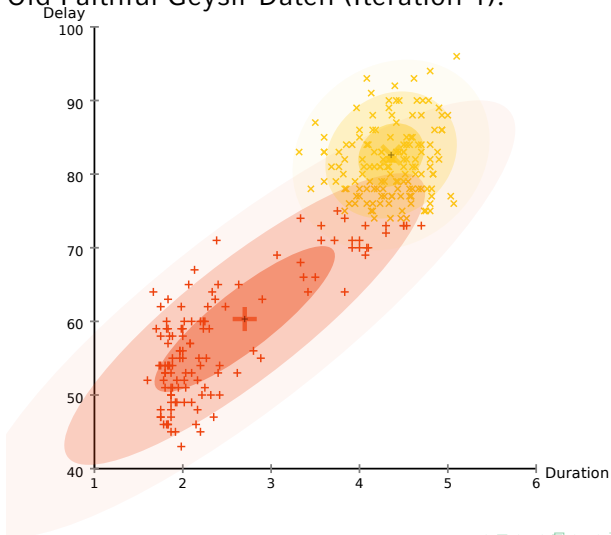
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 1):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

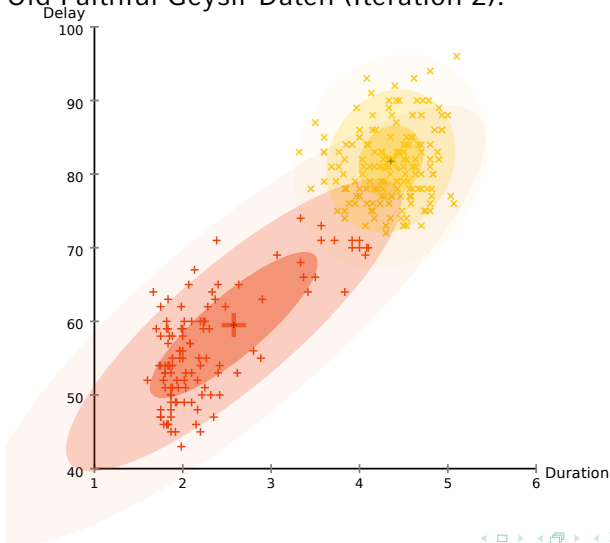
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 2):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

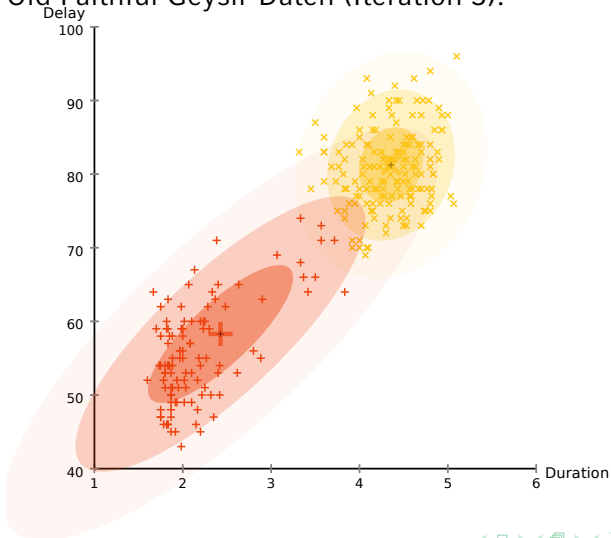
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 3):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

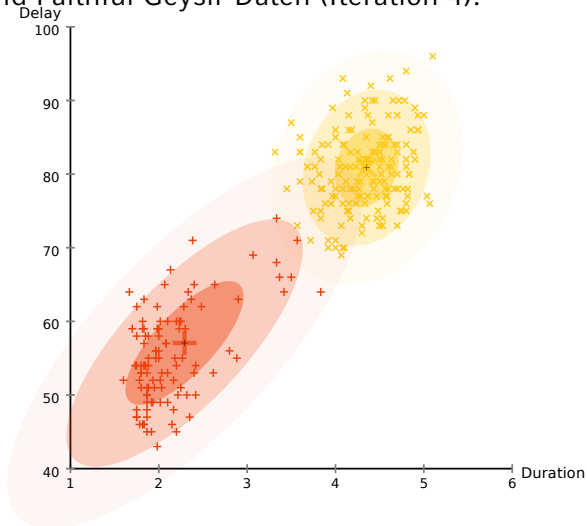
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 4):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

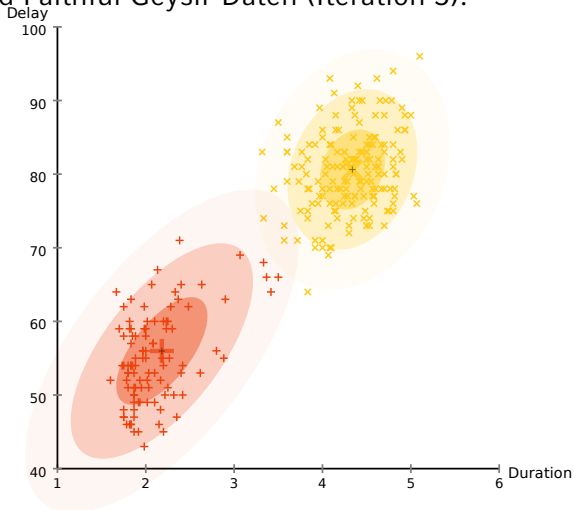
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 5):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

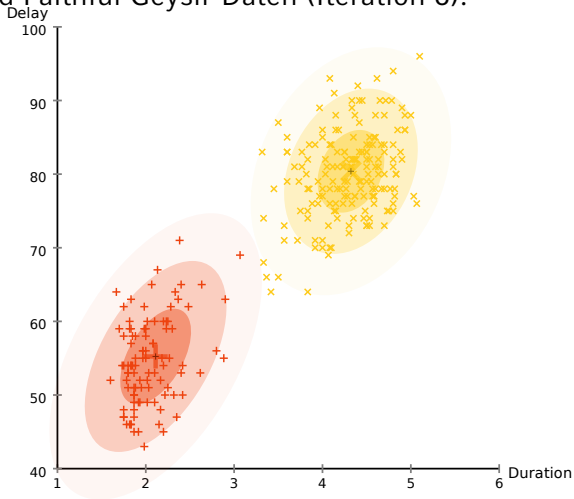
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 6):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

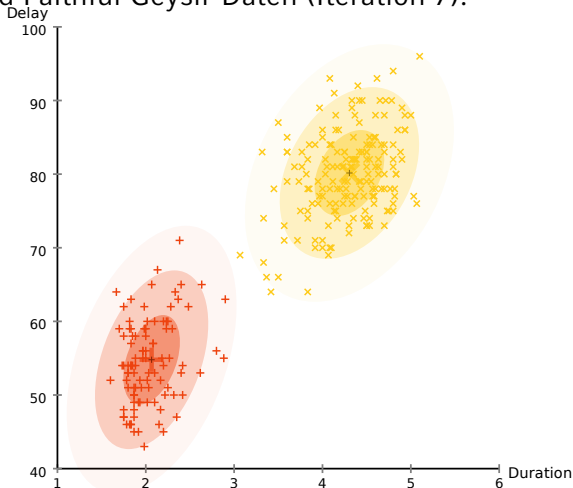
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 7):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

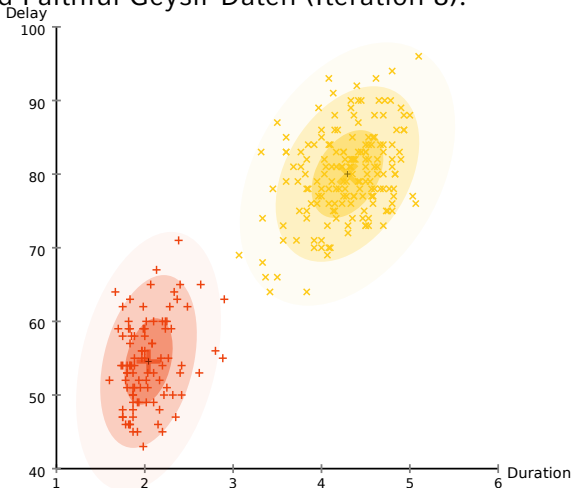
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 8):



$\epsilon = 1.1$
 $\text{minPts} = 2$

$\epsilon = 1.1$
 $\text{minPts} = 3$

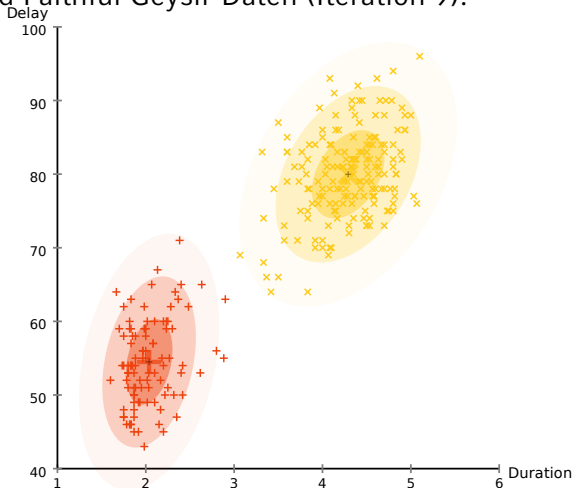
$\epsilon = 1.1$
 $\text{minPts} = 4$

$\epsilon = 2.1$
 $\text{minPts} = 4$

$\epsilon = 4.1$
 $\text{minPts} = 5$

$\epsilon = 4.1$
 $\text{minPts} = 4$

Old Faithful Geysir Daten (Iteration 9):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

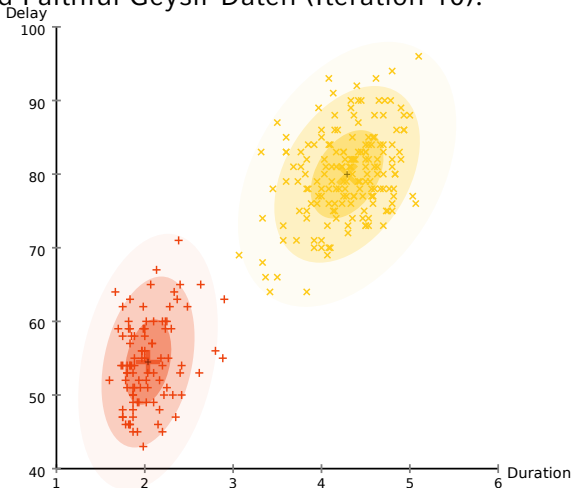
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 10):



$\epsilon = 1.1$
 $\text{minPts} = 2$

$\epsilon = 1.1$
 $\text{minPts} = 3$

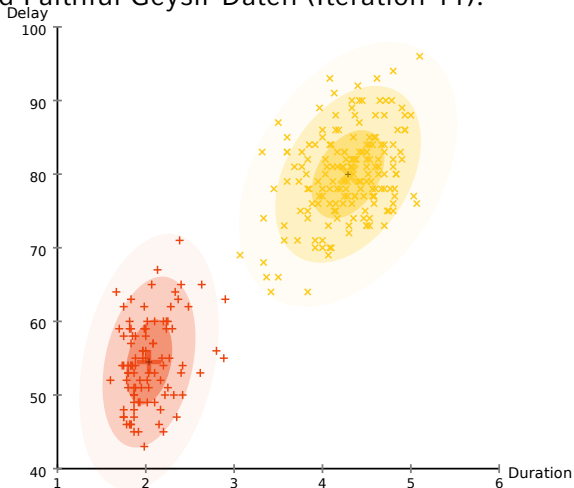
$\epsilon = 1.1$
 $\text{minPts} = 4$

$\epsilon = 2.1$
 $\text{minPts} = 4$

$\epsilon = 4.1$
 $\text{minPts} = 5$

$\epsilon = 4.1$
 $\text{minPts} = 4$

Old Faithful Geysir Daten (Iteration 11):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

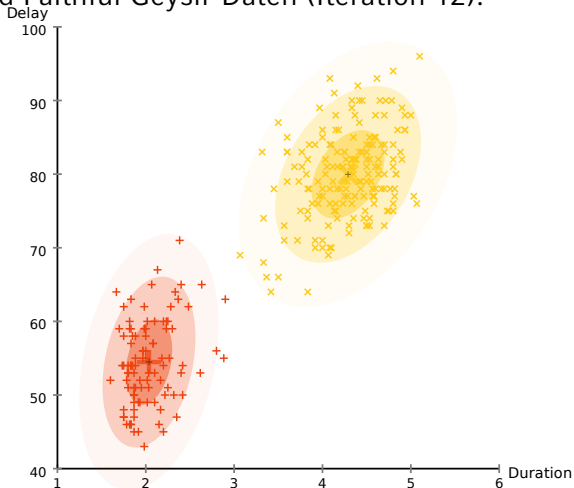
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 12):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

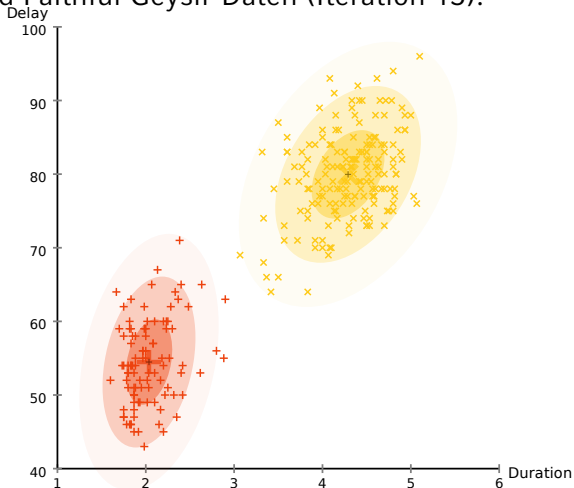
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 13):



$\epsilon = 1.1$
minPts = 2

$\epsilon = 1.1$
minPts = 3

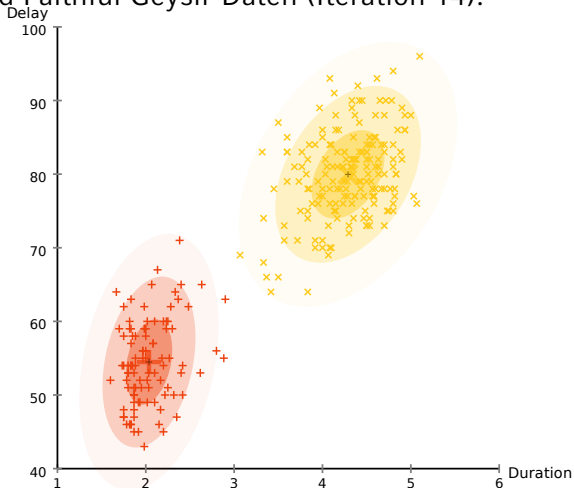
$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

Old Faithful Geysir Daten (Iteration 14):



Aufgabe 3-1

Aufgabe 3-2

Beispiel

Berechnung

Aufgabe 3-3

$\varepsilon = 1.1$
 $\text{minPts} = 2$

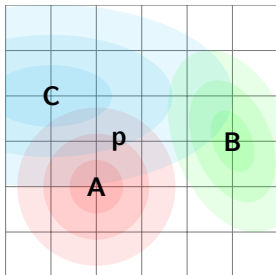
$\varepsilon = 1.1$
 $\text{minPts} = 3$

$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

$\varepsilon = 4.1$
 $\text{minPts} = 4$



Aufgabe 3-1

Aufgabe 3-2

Beispiel

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Aufgabe 3-3

$\varepsilon = 1.1$
minPts = 2

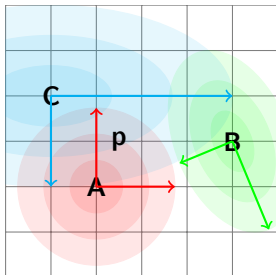
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



$\varepsilon = 1.1$
 $\text{minPts} = 2$

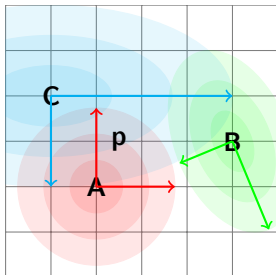
$\varepsilon = 1.1$
 $\text{minPts} = 3$

$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

$\varepsilon = 4.1$
 $\text{minPts} = 4$



$$\Sigma_A = \begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix} \quad \Sigma_A^{-1} = \begin{pmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{3} \end{pmatrix}$$

$\varepsilon = 1.1$
minPts = 2

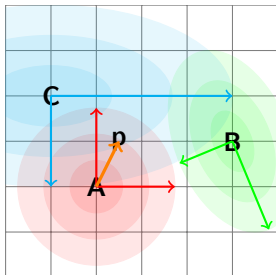
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

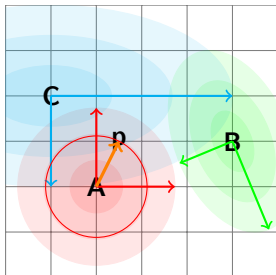
$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



$$\Sigma_A = \begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix} \quad \Sigma_A^{-1} = \begin{pmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{3} \end{pmatrix}$$

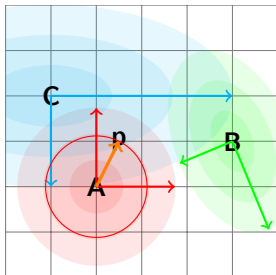
$$p - \mu_A = (0.5, 1)$$



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$$p - \mu_A = (0.5, 1)$$

$$dist^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 0.41666$$



$$\Sigma_A = \begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix} \quad \Sigma_A^{-1} = \begin{pmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{3} \end{pmatrix}$$

$$p - \mu_A = (0.5, 1)$$

$$\text{dist}^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 0.41666$$

$$\begin{aligned} \text{prob}_A &\approx \frac{1}{\sqrt{(2\pi)^2 \cdot 9}} e^{-\frac{1}{2} 0.41666} \\ &\approx 0.04307456 \end{aligned}$$

$\varepsilon = 1.1$
minPts = 2

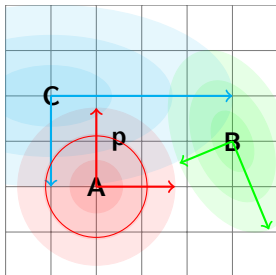
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

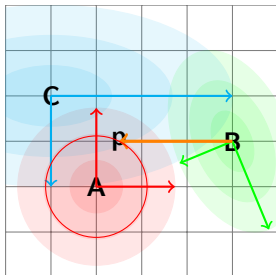
$\varepsilon = 2.1$
minPts = 4

$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4

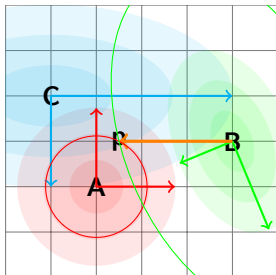


$$\Sigma_B^{-1} \approx \begin{pmatrix} 0.571428 & -0.142857 \\ -0.142857 & 0.285714 \end{pmatrix}$$



$$\Sigma_B^{-1} \approx \begin{pmatrix} 0.571428 & -0.142857 \\ -0.142857 & 0.285714 \end{pmatrix}$$

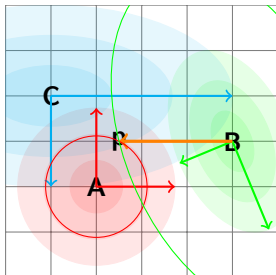
$$p - \mu_B = (-2.5, 0)$$



$$\Sigma_B^{-1} \approx \begin{pmatrix} 0.571428 & -0.142857 \\ -0.142857 & 0.285714 \end{pmatrix}$$

$$p - \mu_B = (-2.5, 0)$$

$$dist^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 3.5714285$$



$$\Sigma_B^{-1} \approx \begin{pmatrix} 0.571428 & -0.142857 \\ -0.142857 & 0.285714 \end{pmatrix}$$

$$p - \mu_B = (-2.5, 0)$$

$$\text{dist}^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 3.5714285$$

$$\begin{aligned} \text{prob}_B &\approx \frac{1}{\sqrt{(2\pi)^2 \cdot 7}} e^{-\frac{1}{2} 3.5714285} \\ &\approx 0.01008661 \end{aligned}$$

$\varepsilon = 1.1$
minPts = 2

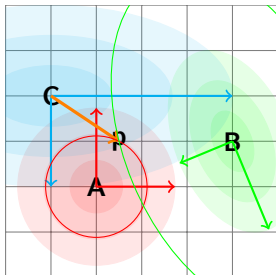
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



$$\Sigma_C = \begin{pmatrix} 16 & 0 \\ 0 & 4 \end{pmatrix} \quad \Sigma_C^{-1} = \begin{pmatrix} \frac{1}{16} & 0 \\ 0 & \frac{1}{4} \end{pmatrix}$$

$\varepsilon = 1.1$
minPts = 2

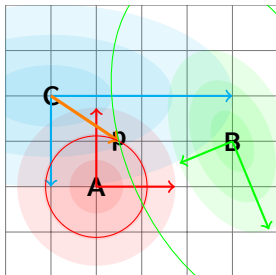
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

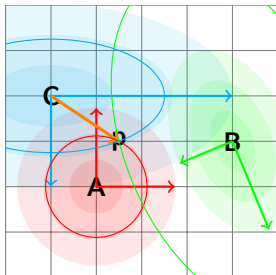
$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



$$\Sigma_C = \begin{pmatrix} 16 & 0 \\ 0 & 4 \end{pmatrix} \quad \Sigma_C^{-1} = \begin{pmatrix} \frac{1}{16} & 0 \\ 0 & \frac{1}{4} \end{pmatrix}$$

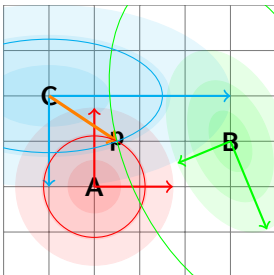
$$p - \mu_C = (1.5, -1)$$



$$\Sigma_C = \begin{pmatrix} 16 & 0 \\ 0 & 4 \end{pmatrix} \quad \Sigma_C^{-1} = \begin{pmatrix} \frac{1}{16} & 0 \\ 0 & \frac{1}{4} \end{pmatrix}$$

$$p - \mu_C = (1.5, -1)$$

$$dist^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 0.390625$$



$$\Sigma_C = \begin{pmatrix} 16 & 0 \\ 0 & 4 \end{pmatrix} \quad \Sigma_C^{-1} = \begin{pmatrix} \frac{1}{16} & 0 \\ 0 & \frac{1}{4} \end{pmatrix}$$

$$p - \mu_C = (1.5, -1)$$

$$dist^2 = (p - \mu)^T \Sigma^{-1} (p - \mu) \approx 0.390625$$

$$\begin{aligned} prob_C &\approx \frac{1}{\sqrt{(2\pi)^2 \cdot 64}} e^{-\frac{1}{2} 0.390625} \\ &\approx 0.01636466 \end{aligned}$$

$\varepsilon = 1.1$
minPts = 2

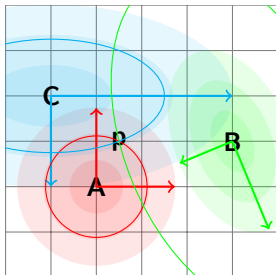
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



	<i>A</i>	<i>B</i>	<i>C</i>
<i>prob</i>	0.043075	0.010087	0.016365
<i>size</i>	30%	20%	50%

$\varepsilon = 1.1$
minPts = 2

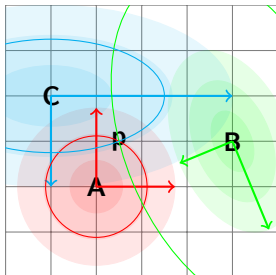
$\varepsilon = 1.1$
minPts = 3

$\varepsilon = 1.1$
minPts = 4

$\varepsilon = 2.1$
minPts = 4

$\varepsilon = 4.1$
minPts = 5

$\varepsilon = 4.1$
minPts = 4



	<i>A</i>	<i>B</i>	<i>C</i>
<i>prob</i>	0.043075	0.010087	0.016365
<i>size</i>	30%	20%	50%
<i>score</i>	0.012922	0.002017	0.008182

$\epsilon = 1.1$
minPts = 2

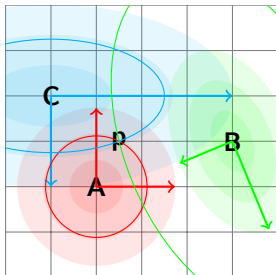
$\epsilon = 1.1$
minPts = 3

$\epsilon = 1.1$
minPts = 4

$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4



	<i>A</i>	<i>B</i>	<i>C</i>
<i>prob</i>	0.043075	0.010087	0.016365
<i>size</i>	30%	20%	50%
<i>score</i>	0.012922	0.002017	0.008182
<i>sum</i>	divide by 0.023122		

$\epsilon = 1.1$
minPts = 2

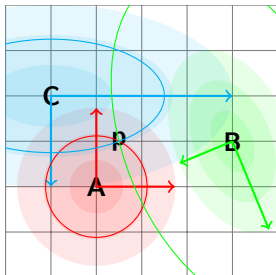
$\epsilon = 1.1$
minPts = 3

$\epsilon = 1.1$
minPts = 4

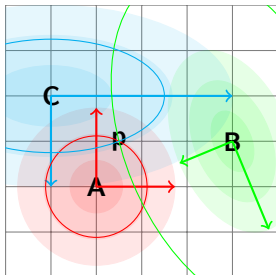
$\epsilon = 2.1$
minPts = 4

$\epsilon = 4.1$
minPts = 5

$\epsilon = 4.1$
minPts = 4

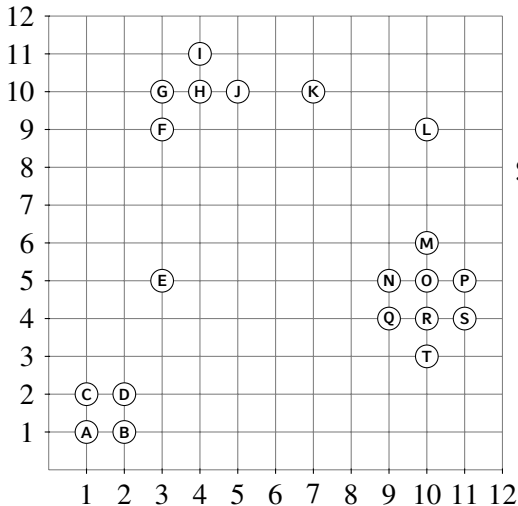


	A	B	C
<i>prob</i>	0.043075	0.010087	0.016365
<i>size</i>	30%	20%	50%
<i>score</i>	0.012922	0.002017	0.008182
<i>sum</i>	divide by 0.023122		
<i>weight</i>	$\approx 55.9\%$	$\approx 8.2\%$	$\approx 35.4\%$



	A	B	C
<i>prob</i>	0.043075	0.010087	0.016365
<i>size</i>	30%	20%	50%
<i>score</i>	0.012922	0.002017	0.008182
<i>sum</i>	divide by 0.023122		
<i>weight</i>	$\approx 55.9\%$	$\approx 8.2\%$	$\approx 35.4\%$

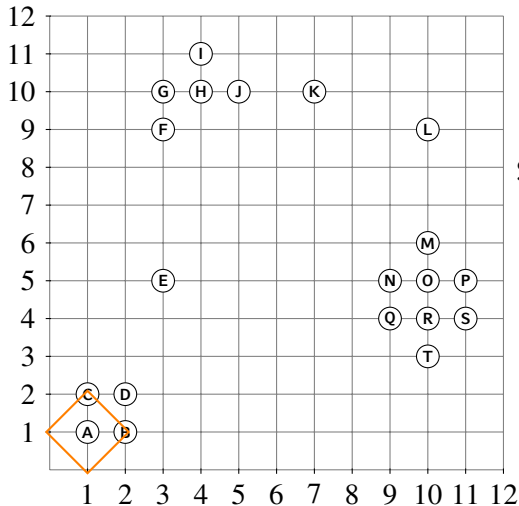
Point p belongs mostly to cluster A!



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

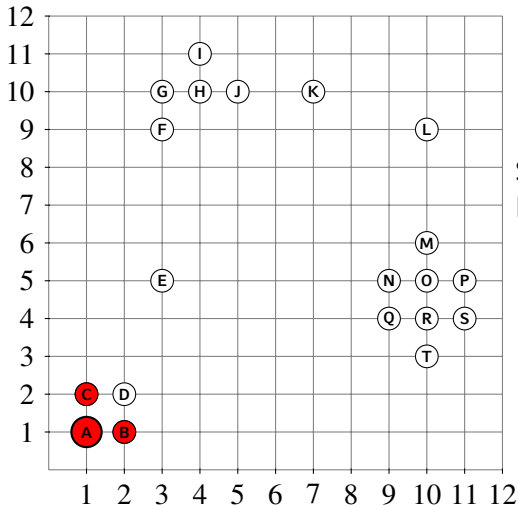
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

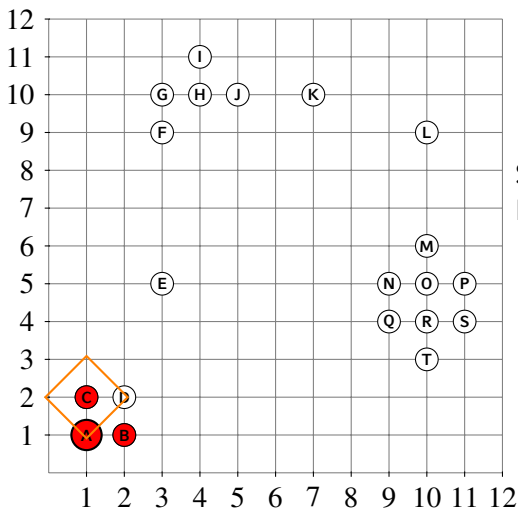
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

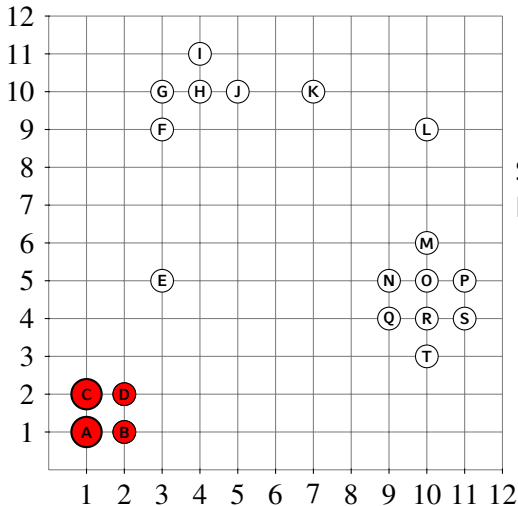
Seed list:
BC



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

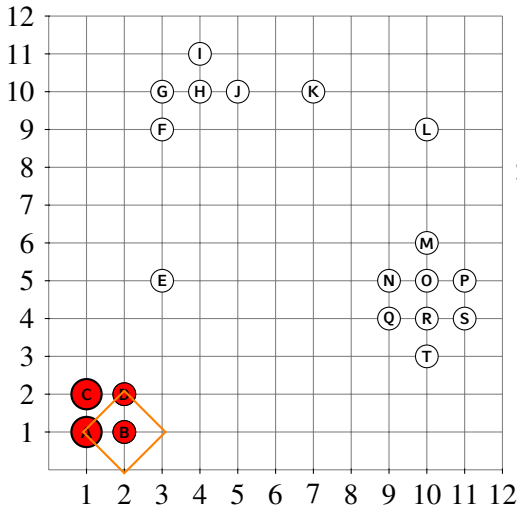
Seed list:
B

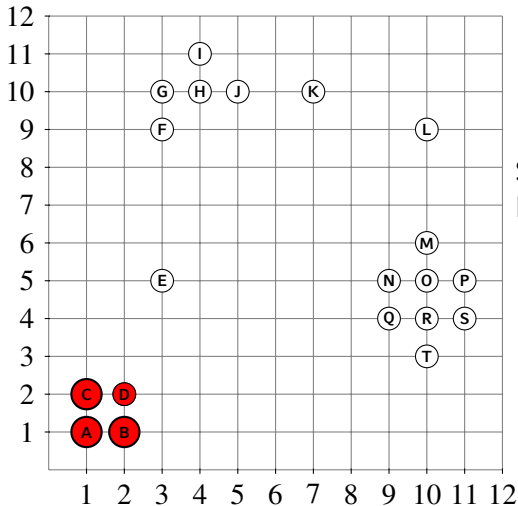


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:
BD

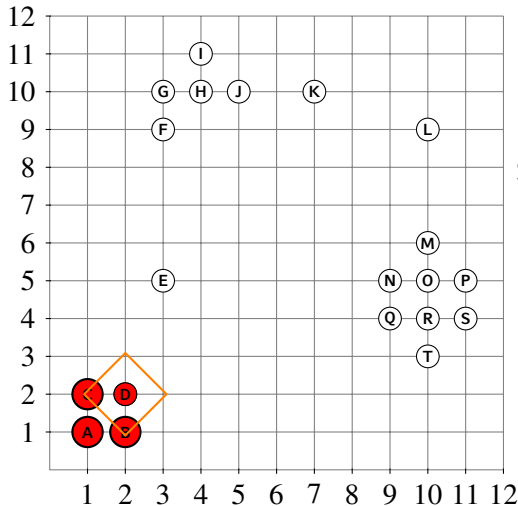




$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

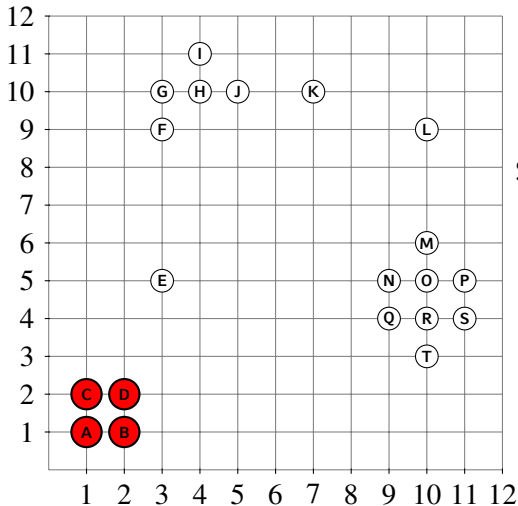
Seed list:
D



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

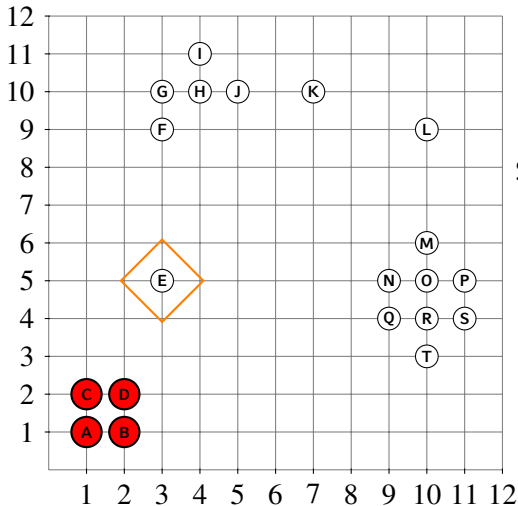
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

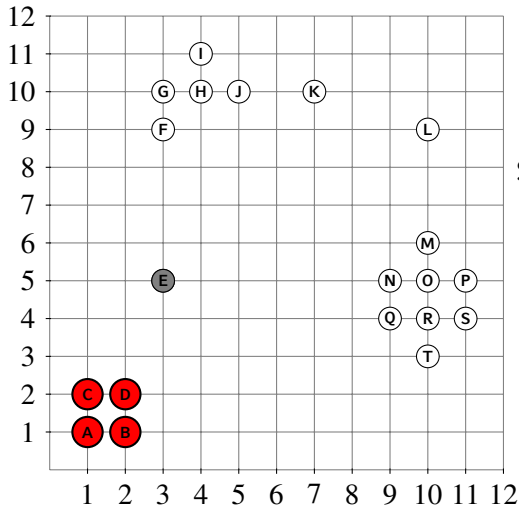
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

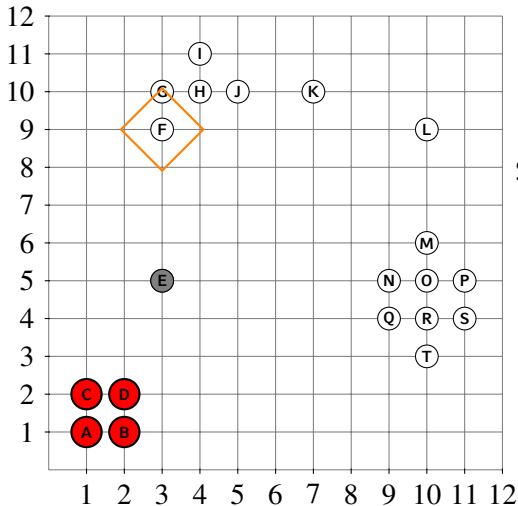
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

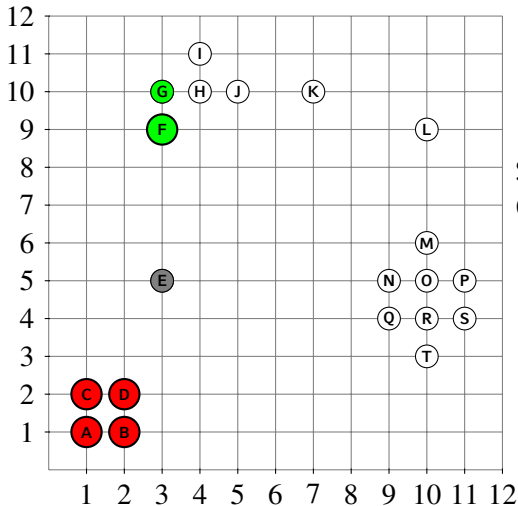
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

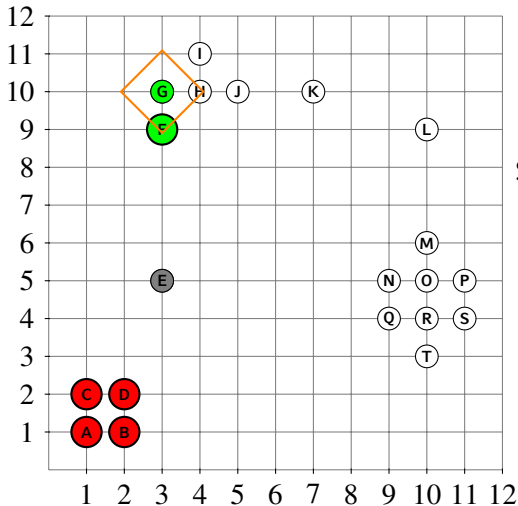


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

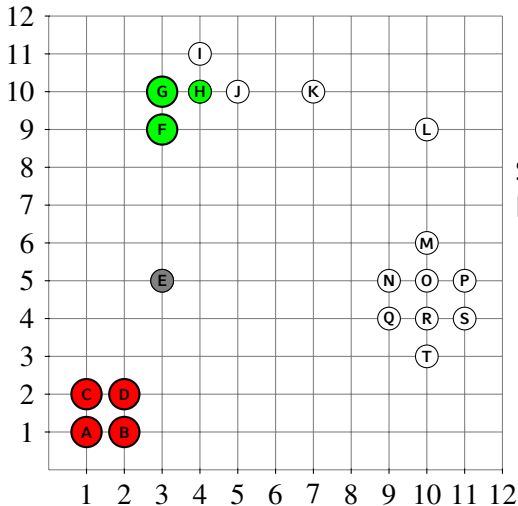
G



$\varepsilon = 1.1$

$\text{minPts} = 2$

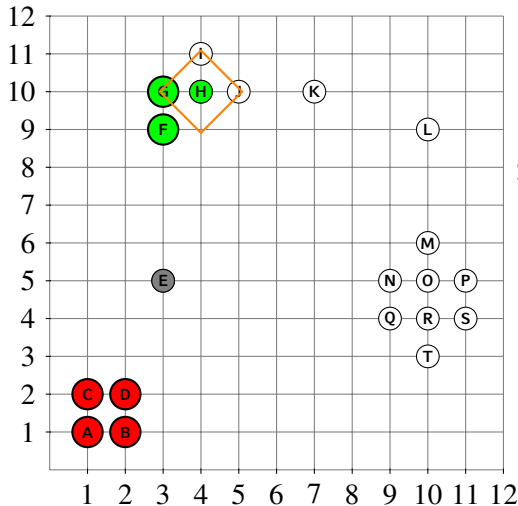
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

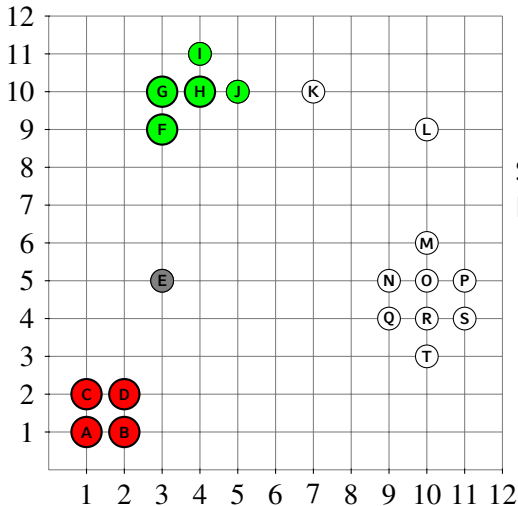
Seed list:
H



$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

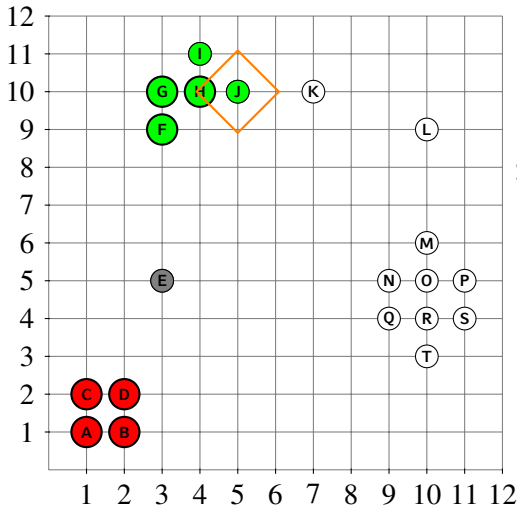


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

IJ

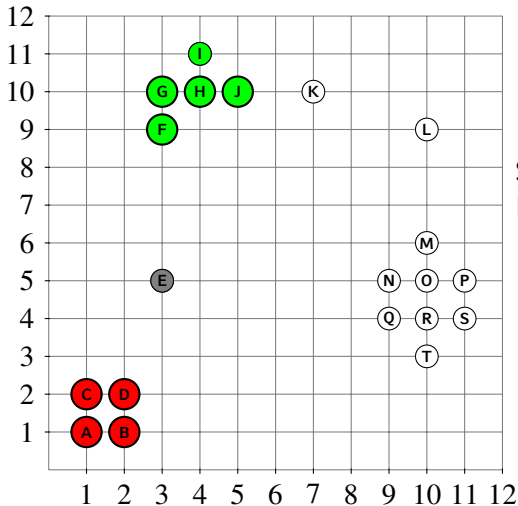


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

I

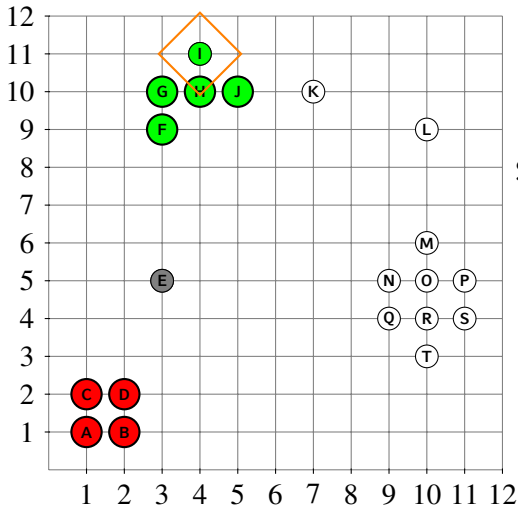


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

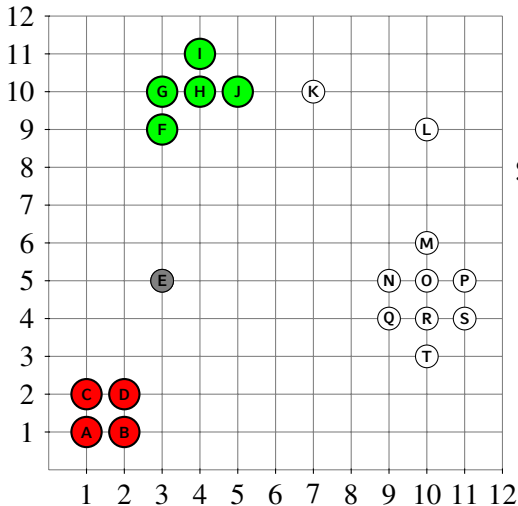
I



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

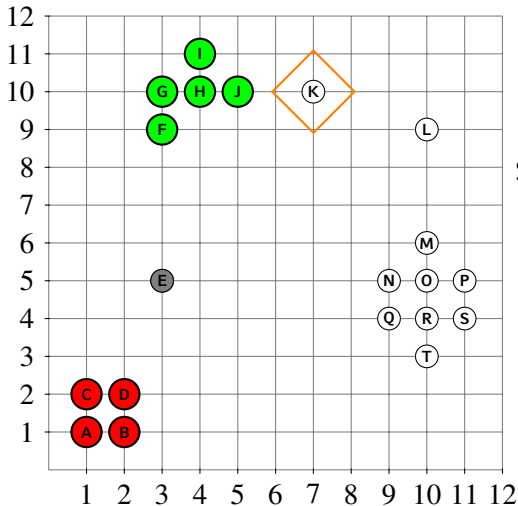
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

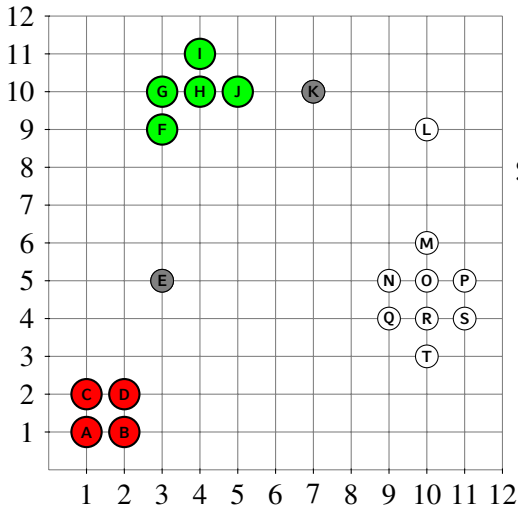
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

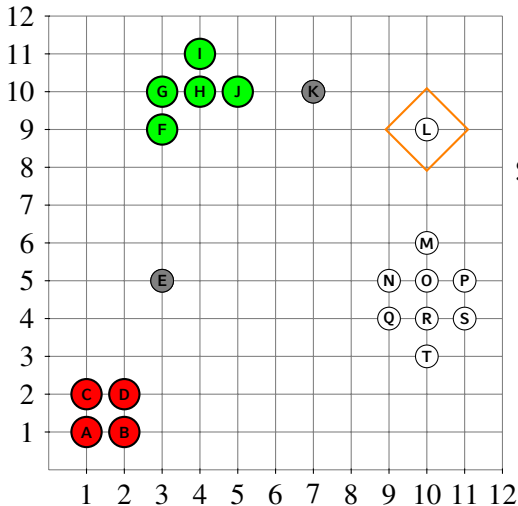
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 2$$

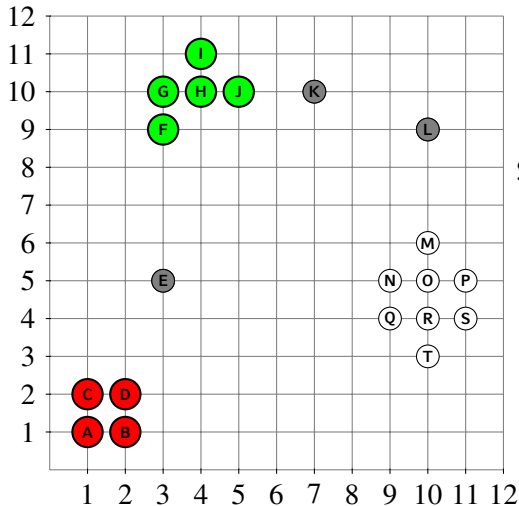
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

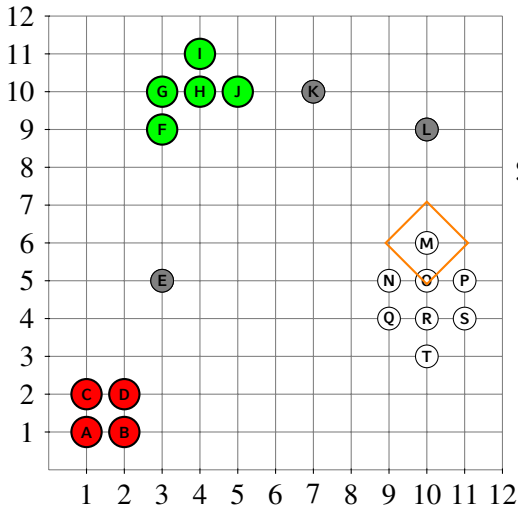
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

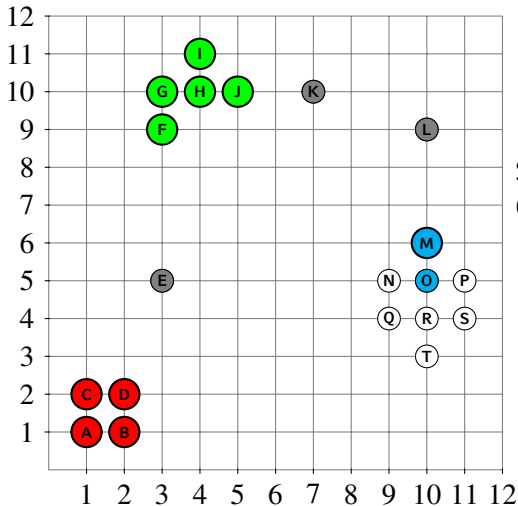
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

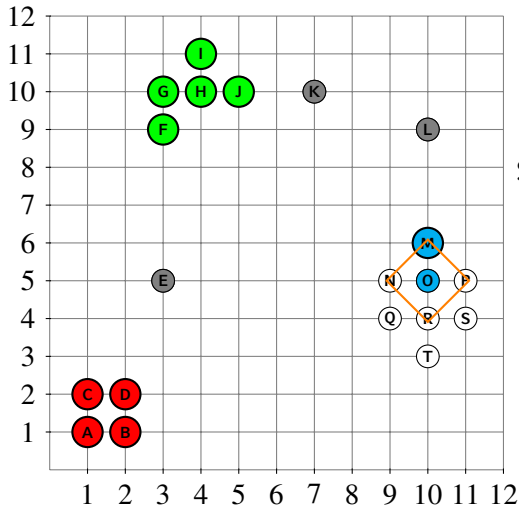
Seed list:



$\varepsilon = 1.1$

$minPts = 2$

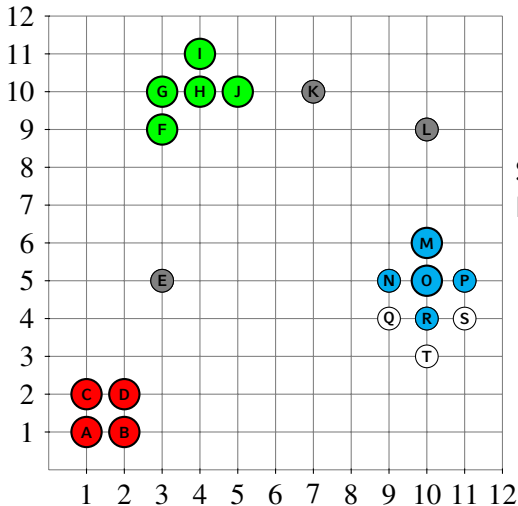
Seed list:
0



$\varepsilon = 1.1$

$\text{minPts} = 2$

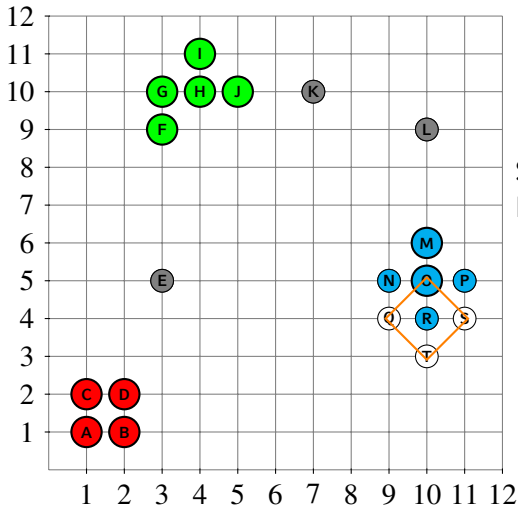
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

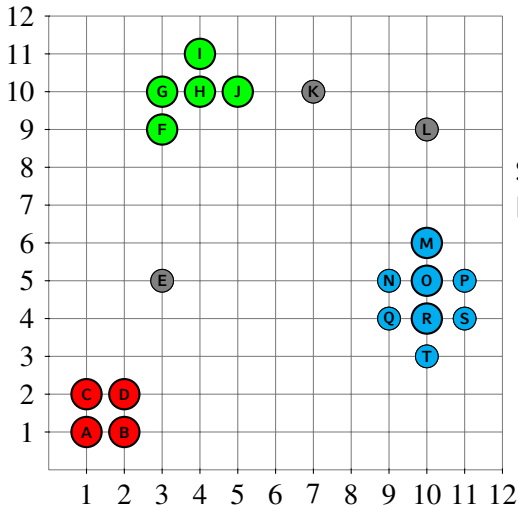
Seed list:
NPR



$\epsilon = 1.1$

$minPts = 2$

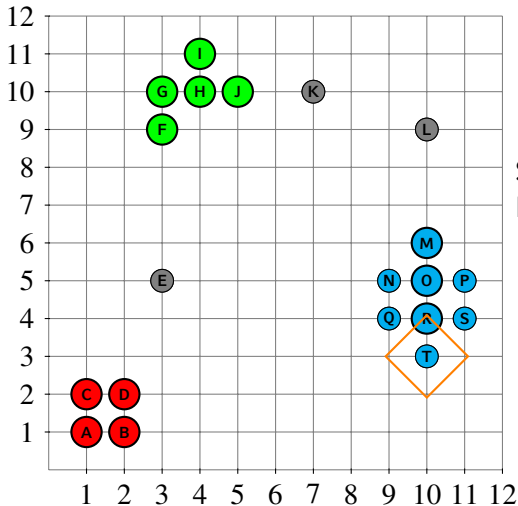
Seed list:
NP



$\varepsilon = 1.1$

$\text{minPts} = 2$

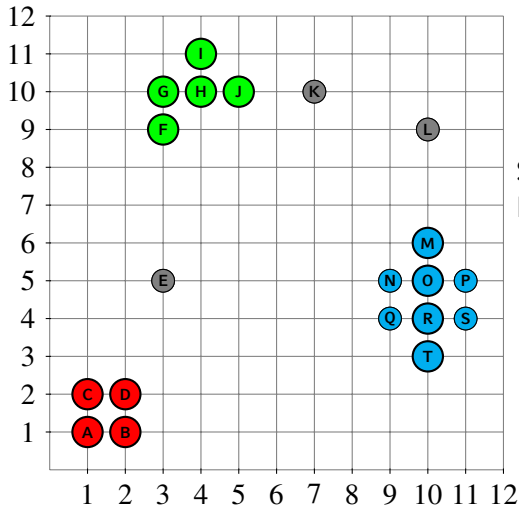
Seed list:
NPQST



$\varepsilon = 1.1$

$\text{minPts} = 2$

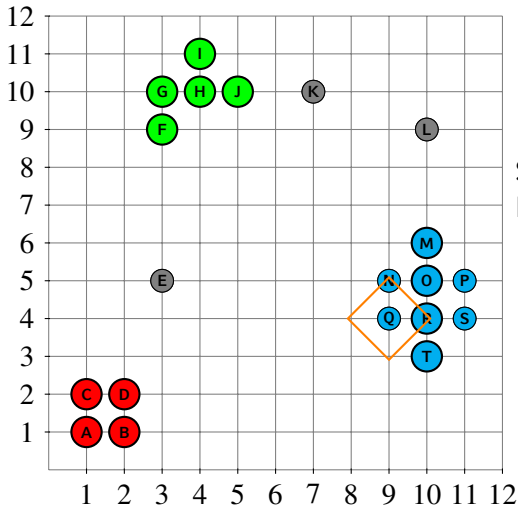
Seed list:
NPQS



$\varepsilon = 1.1$

$\text{minPts} = 2$

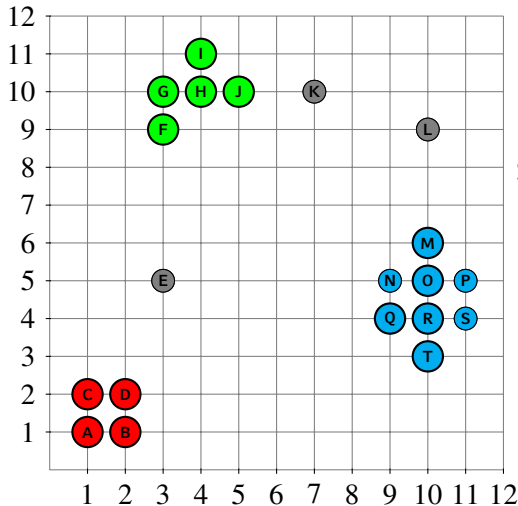
Seed list:
NPQS



$\varepsilon = 1.1$

$\text{minPts} = 2$

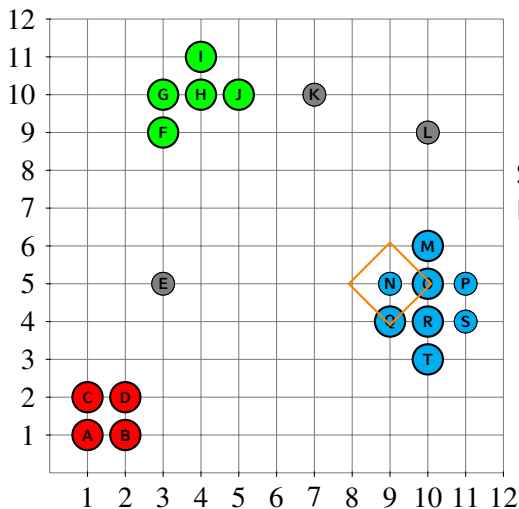
Seed list:
NPS



$\varepsilon = 1.1$

$\text{minPts} = 2$

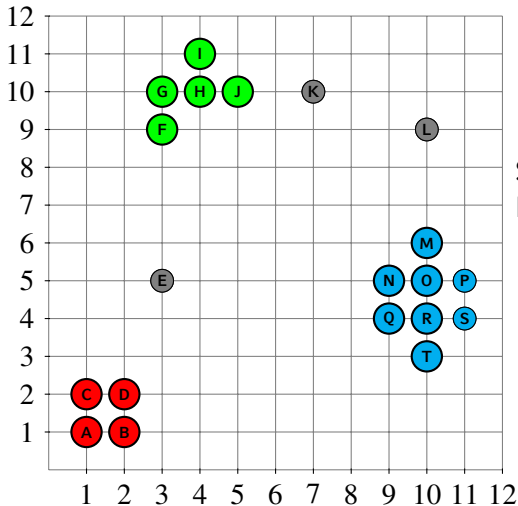
Seed list:
NPS



$\varepsilon = 1.1$

$\text{minPts} = 2$

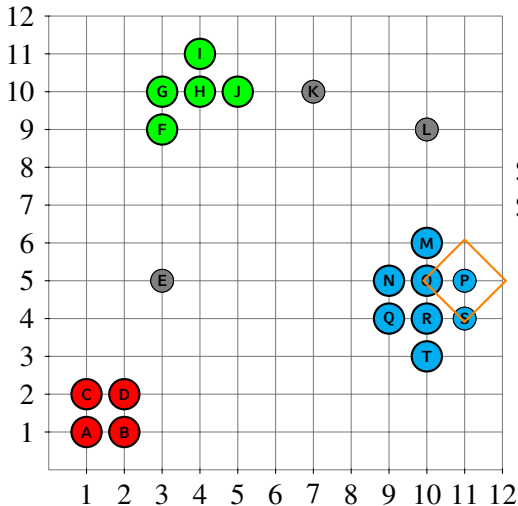
Seed list:
PS



$\varepsilon = 1.1$

$\text{minPts} = 2$

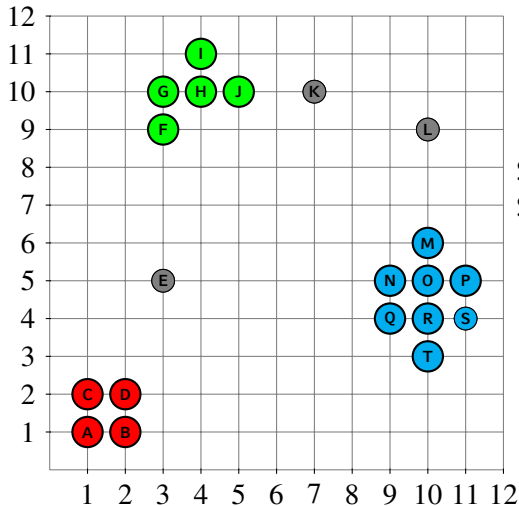
Seed list:
PS



$\epsilon = 1.1$

$\text{minPts} = 2$

Seed list:
S

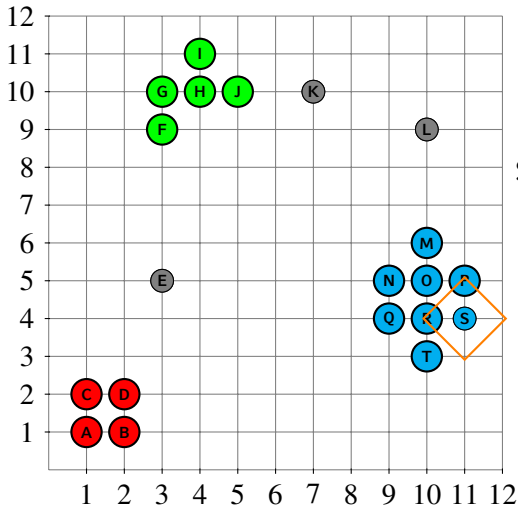


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

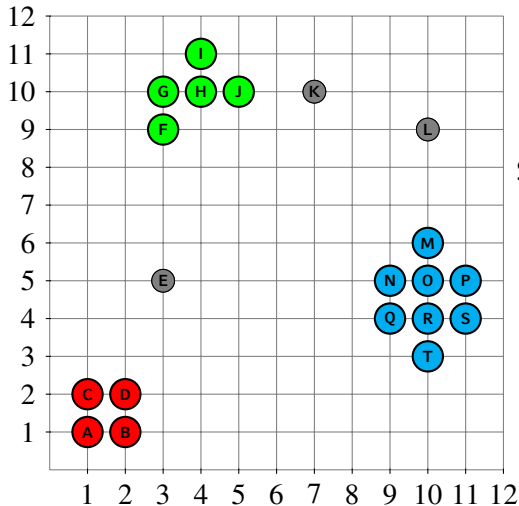
S



$\varepsilon = 1.1$

$\text{minPts} = 2$

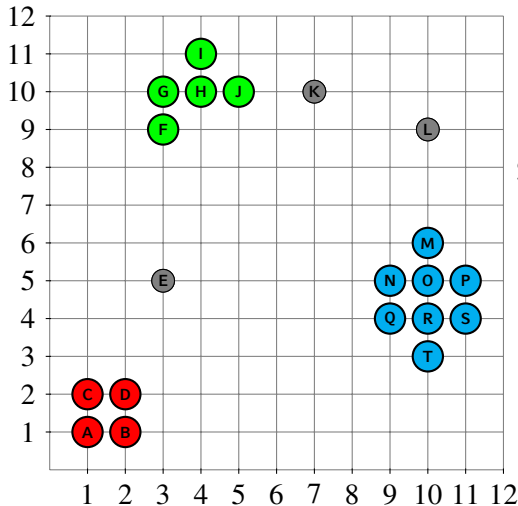
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

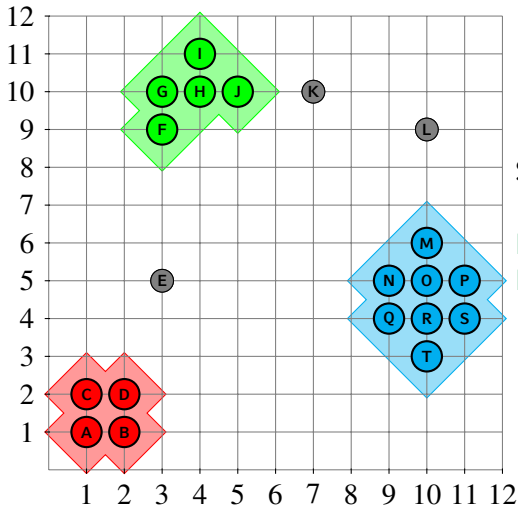


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

Keine
Randpunkte!

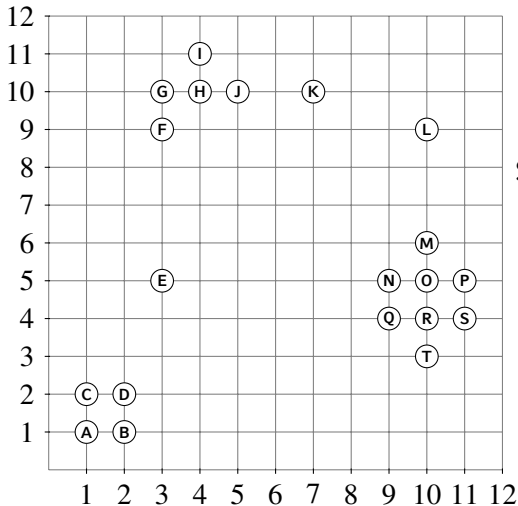


$\varepsilon = 1.1$

$\text{minPts} = 2$

Seed list:

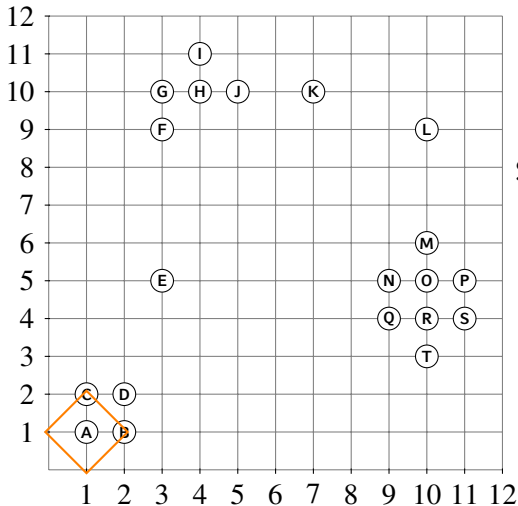
Keine
Randpunkte!



$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

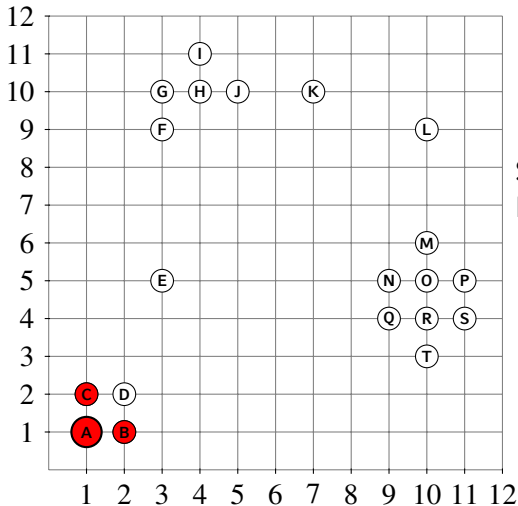
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

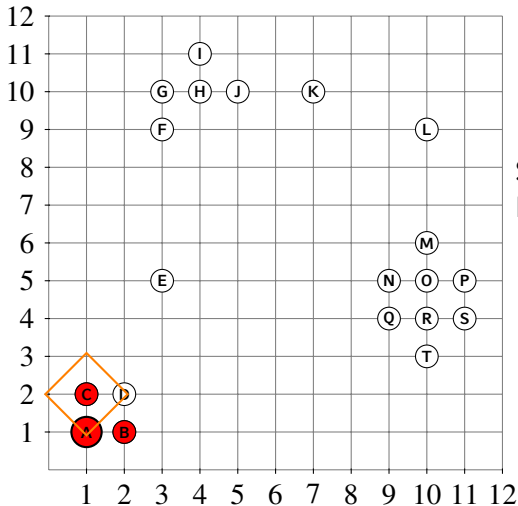
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

Seed list:
BC

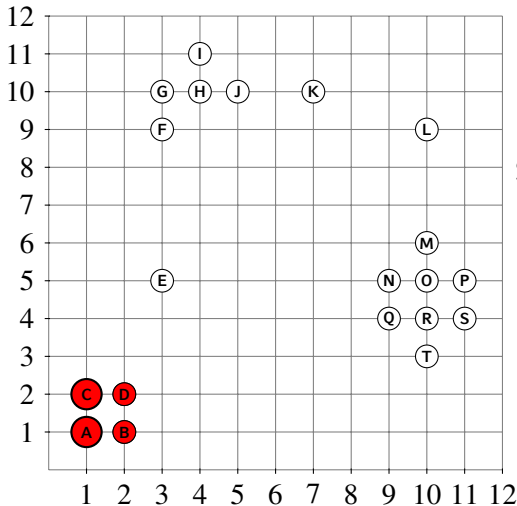


$\epsilon = 1.1$

$\text{minPts} = 3$

Seed list:

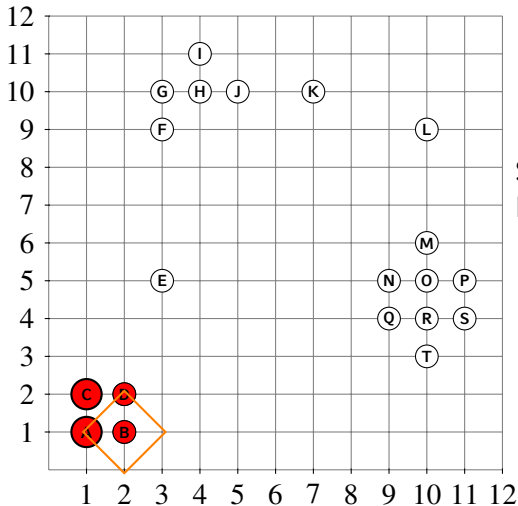
B



$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

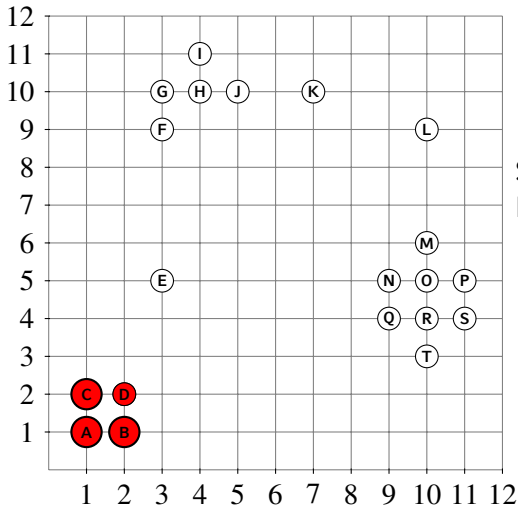
Seed list:
BD



$\varepsilon = 1.1$

$\text{minPts} = 3$

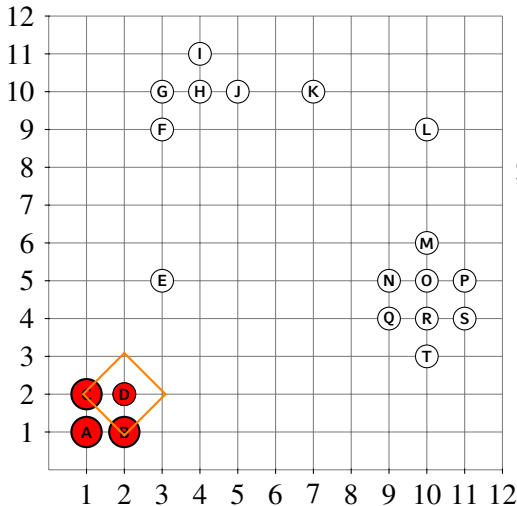
Seed list:
D



$\epsilon = 1.1$

$\text{minPts} = 3$

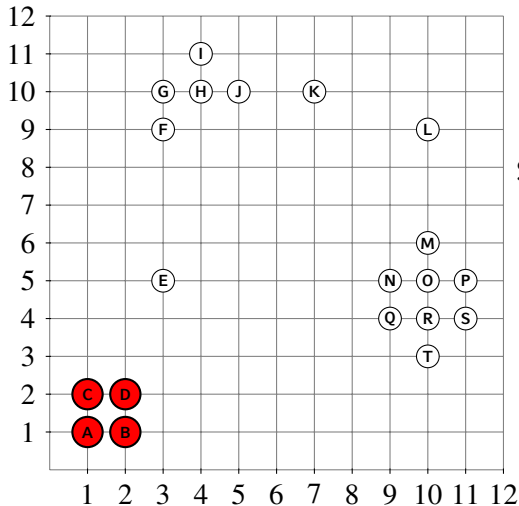
Seed list:
D



$\varepsilon = 1.1$

$\text{minPts} = 3$

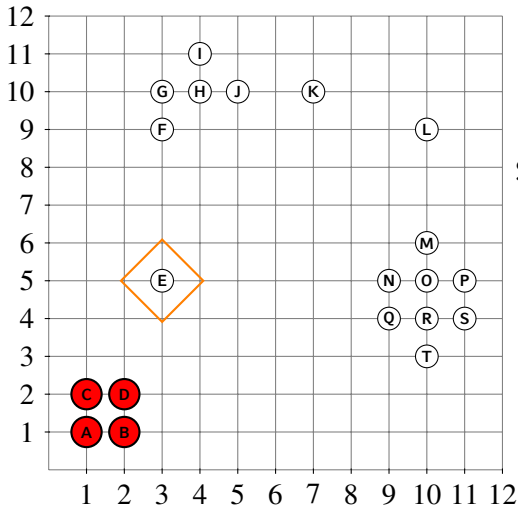
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

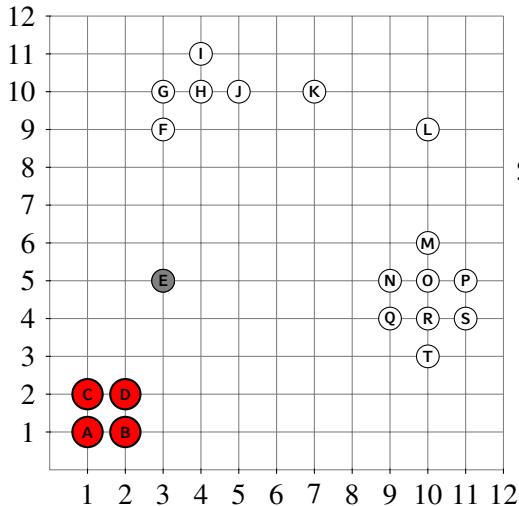
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

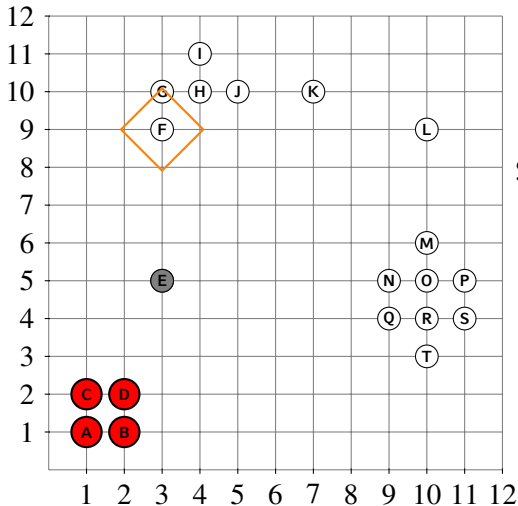
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

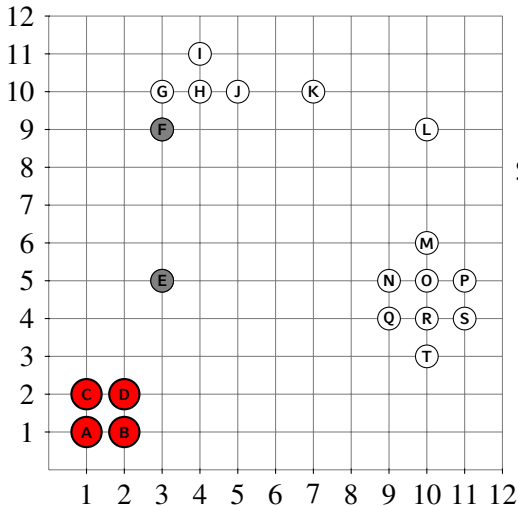
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

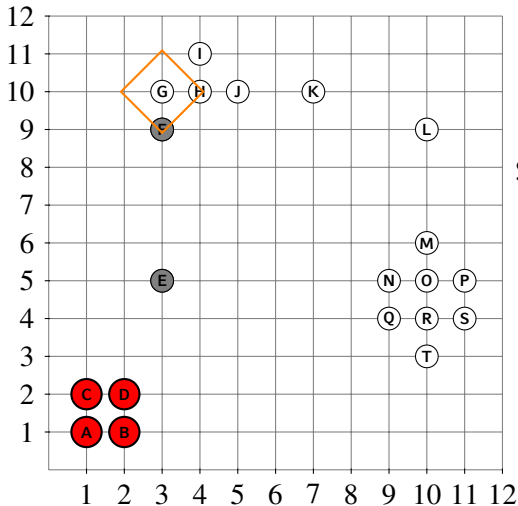
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

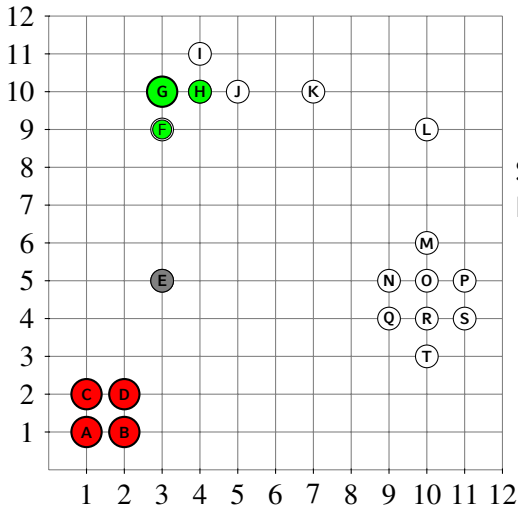
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

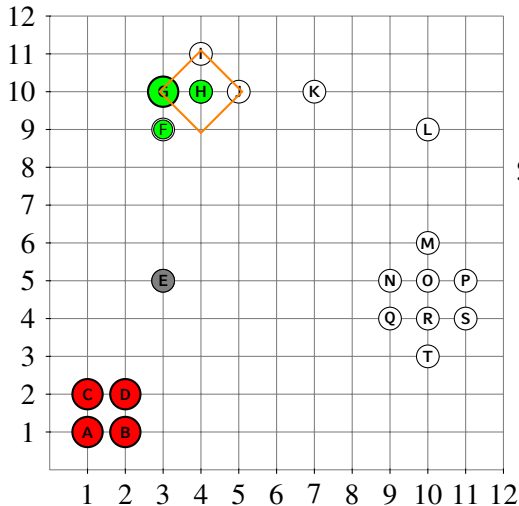
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

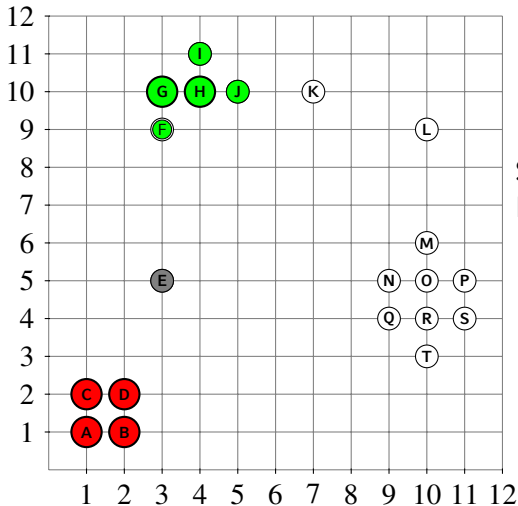
Seed list:
H



$\varepsilon = 1.1$

$\text{minPts} = 3$

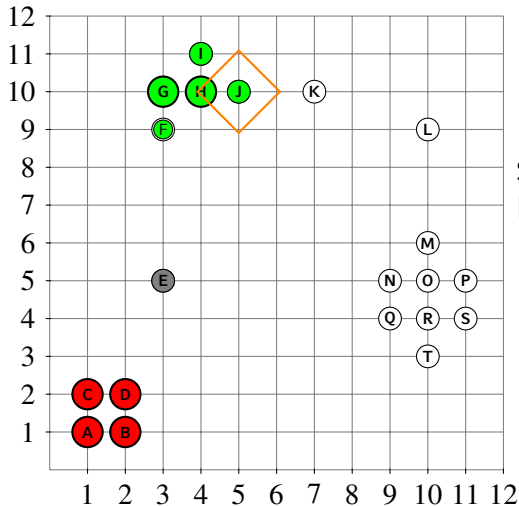
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

Seed list:
IJ

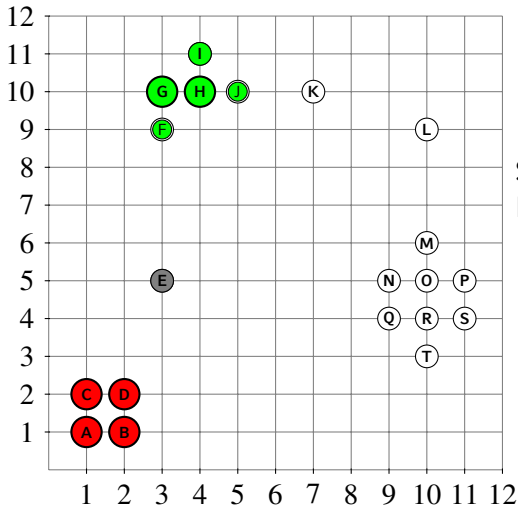


$\varepsilon = 1.1$

$\text{minPts} = 3$

Seed list:

I

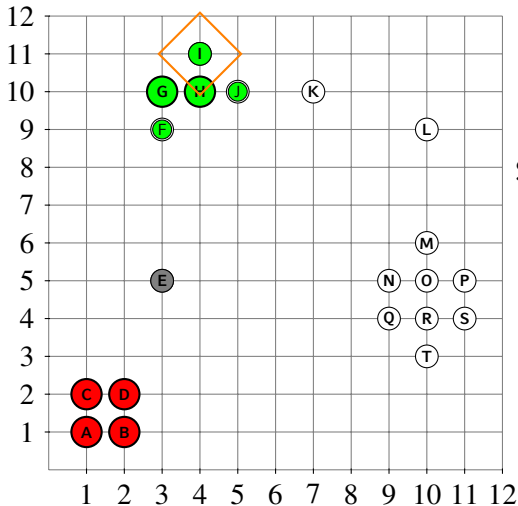


$\varepsilon = 1.1$

$\text{minPts} = 3$

Seed list:

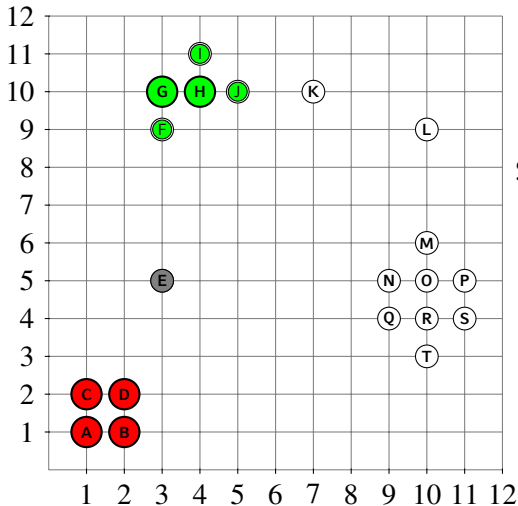
I



$\varepsilon = 1.1$

$\text{minPts} = 3$

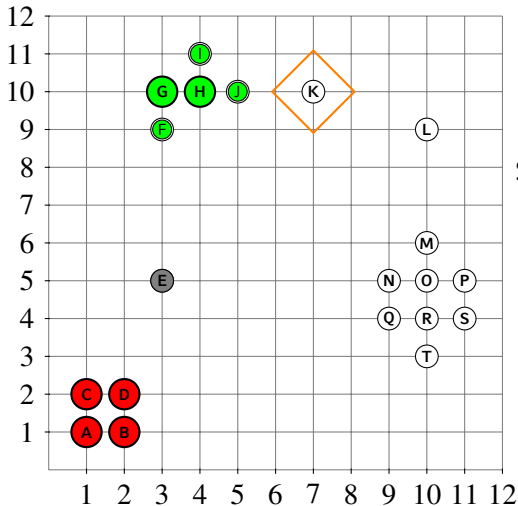
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

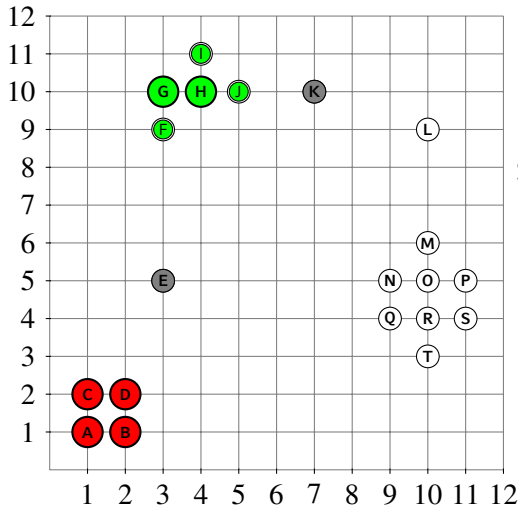
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$\varepsilon = 1.1$

$\text{minPts} = 3$

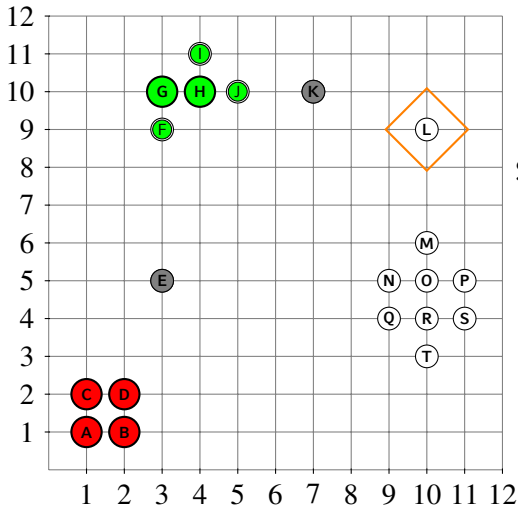
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$\text{minPts} = 3$

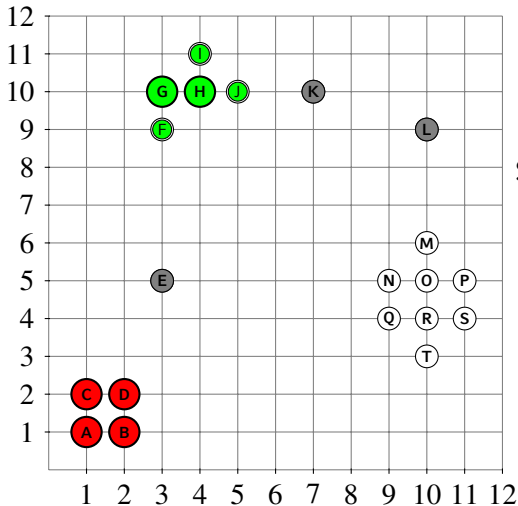
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$\varepsilon = 1.1$

$\text{minPts} = 3$

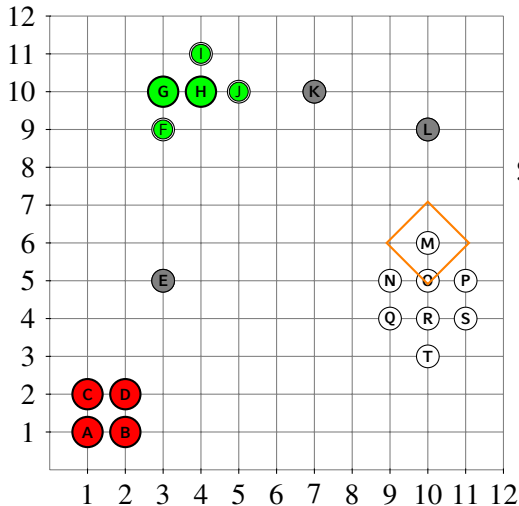
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$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

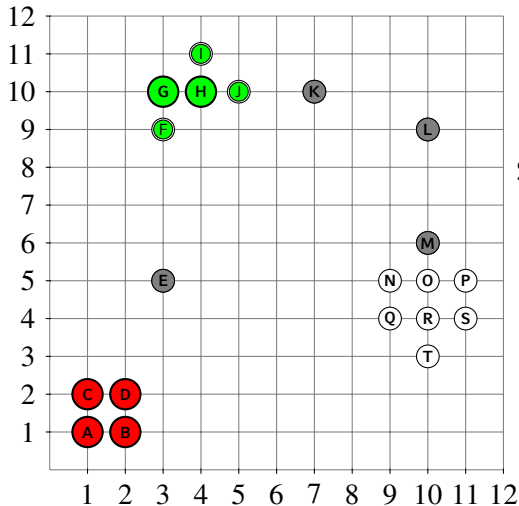
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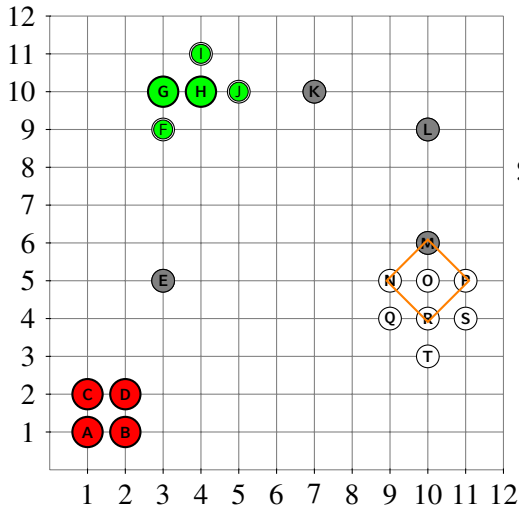
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$\varepsilon = 1.1$

$\text{minPts} = 3$

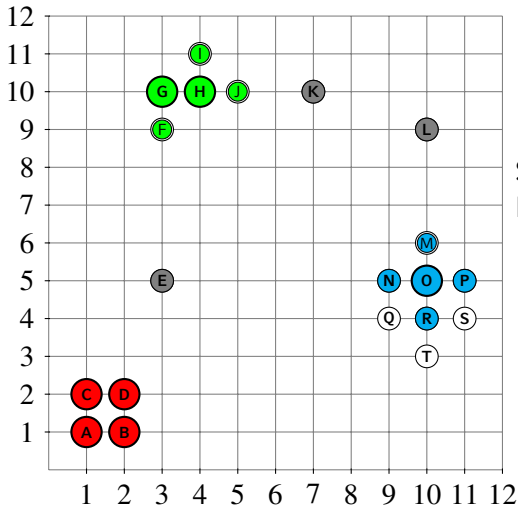
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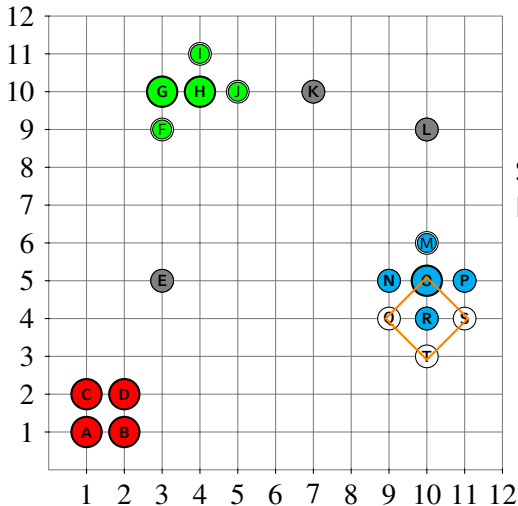
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

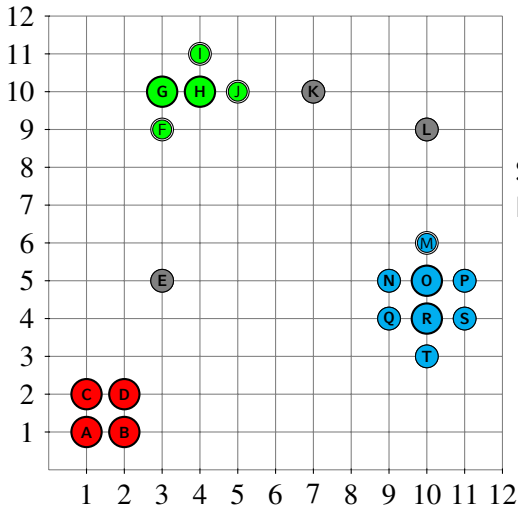
Seed list:
NPR



$\varepsilon = 1.1$

$\text{minPts} = 3$

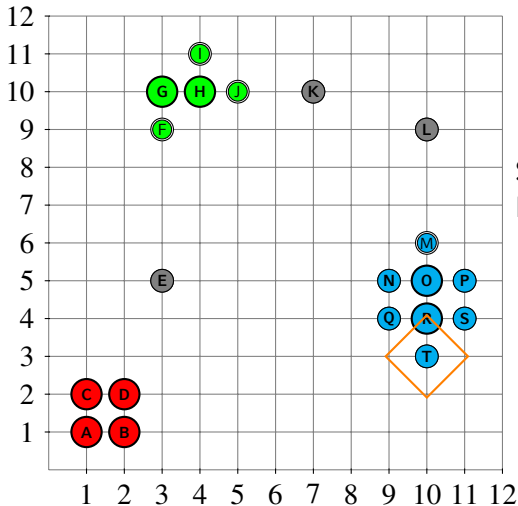
Seed list:
NP



$\varepsilon = 1.1$

$\text{minPts} = 3$

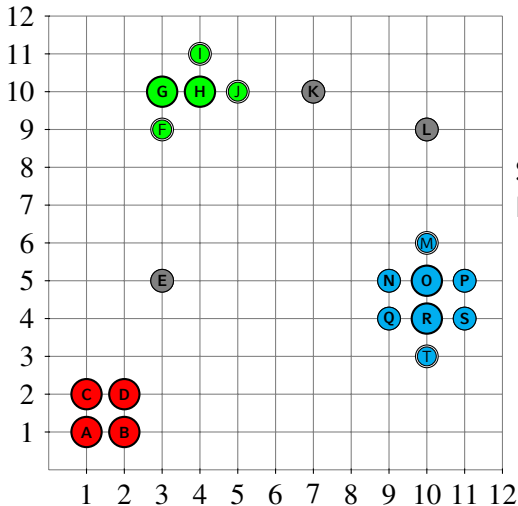
Seed list:
NPQST



$\epsilon = 1.1$

$\text{minPts} = 3$

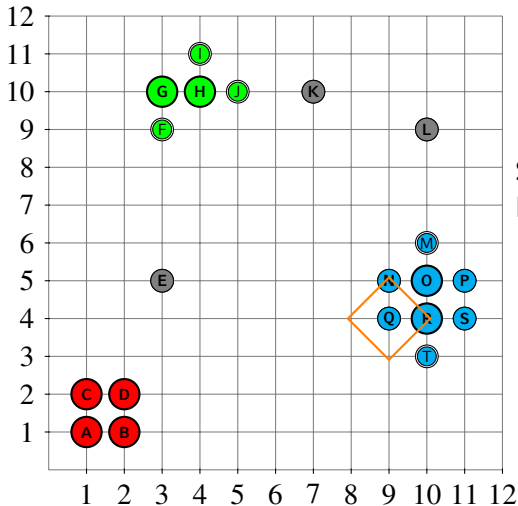
Seed list:
NPQS



$\varepsilon = 1.1$

$\text{minPts} = 3$

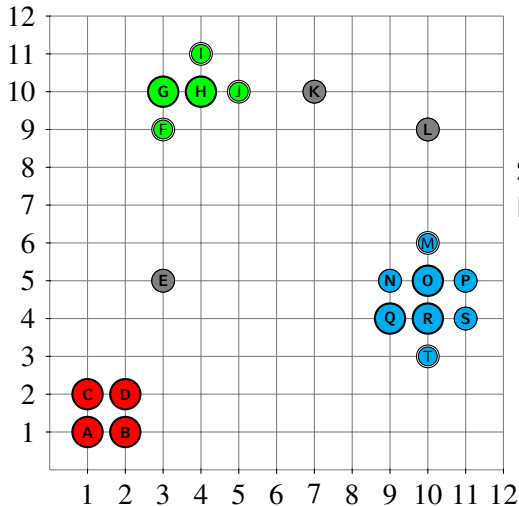
Seed list:
NPQS



$\epsilon = 1.1$

$\text{minPts} = 3$

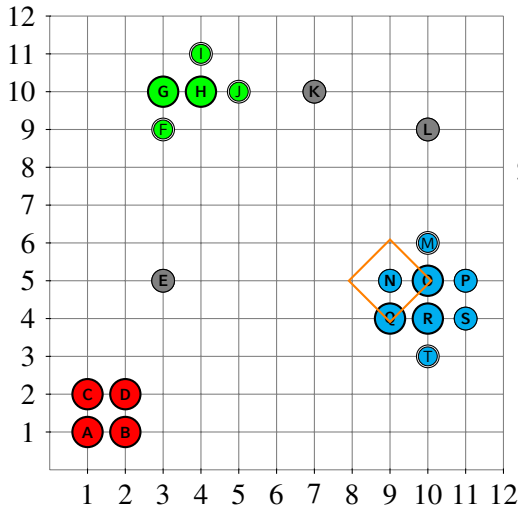
Seed list:
NPS



$\varepsilon = 1.1$

$\text{minPts} = 3$

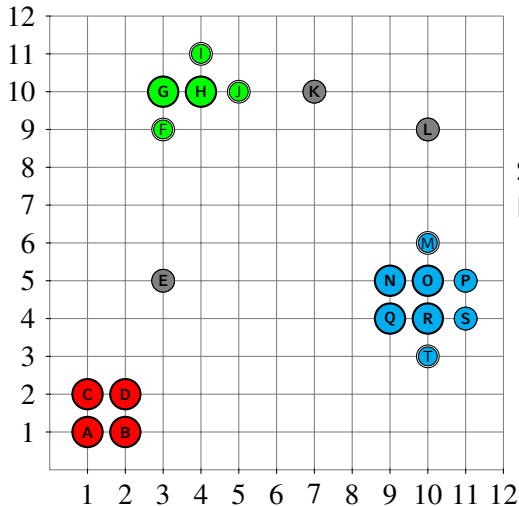
Seed list:
NPS



$\varepsilon = 1.1$

$\text{minPts} = 3$

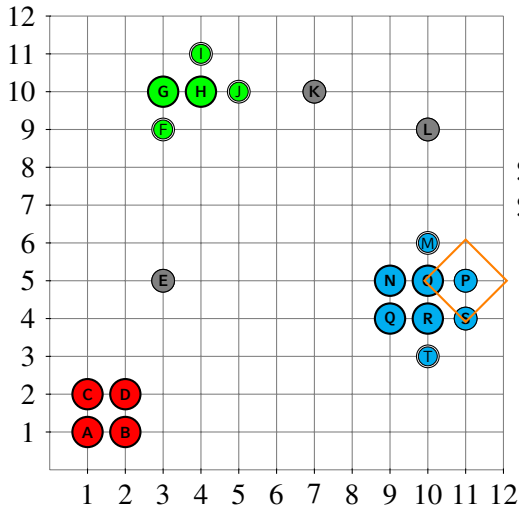
Seed list:
PS



$\epsilon = 1.1$

$\text{minPts} = 3$

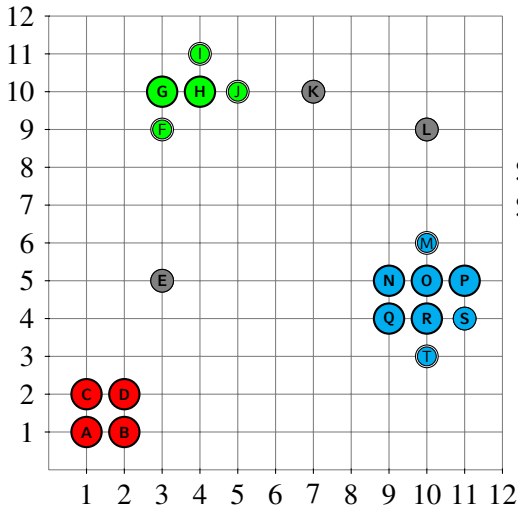
Seed list:
PS



$\epsilon = 1.1$

$\text{minPts} = 3$

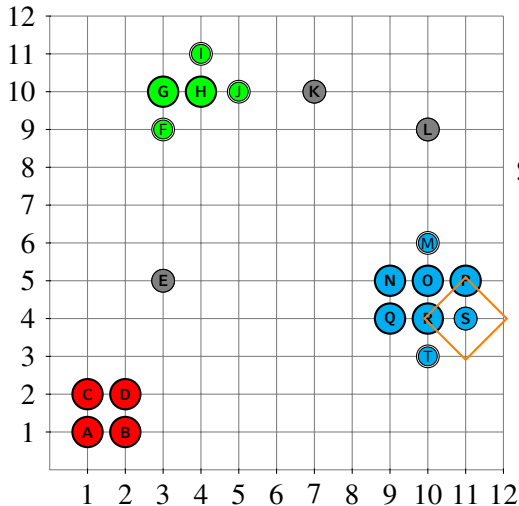
Seed list:
S



$\varepsilon = 1.1$

$\text{minPts} = 3$

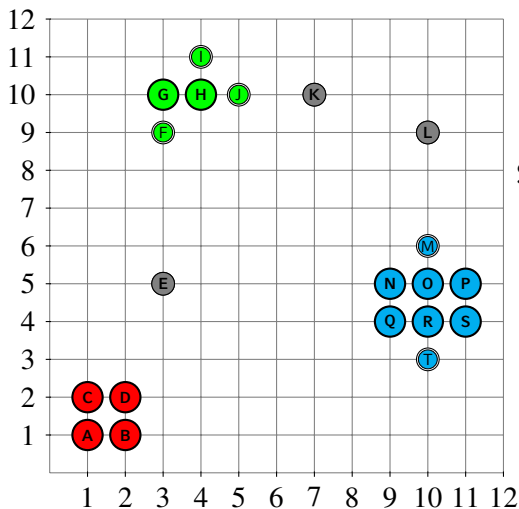
Seed list:
S



$\varepsilon = 1.1$

$\text{minPts} = 3$

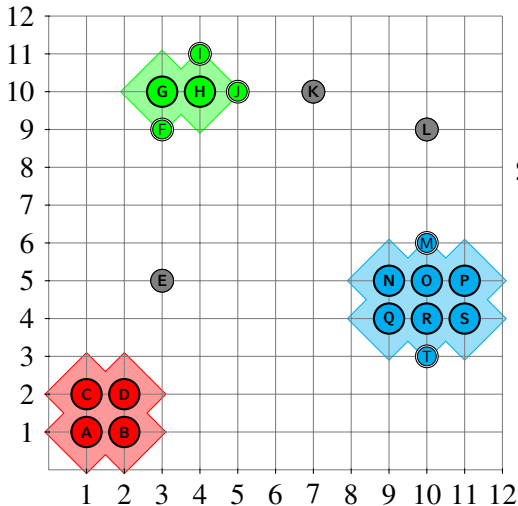
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 3$$

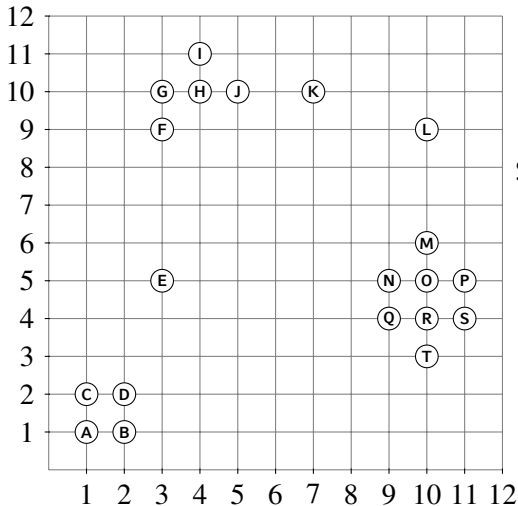
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 3$

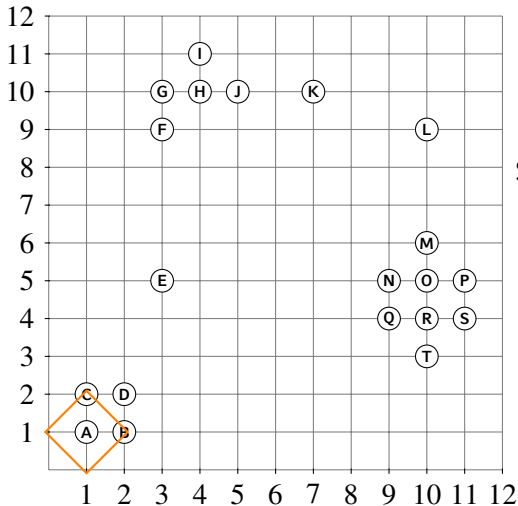
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

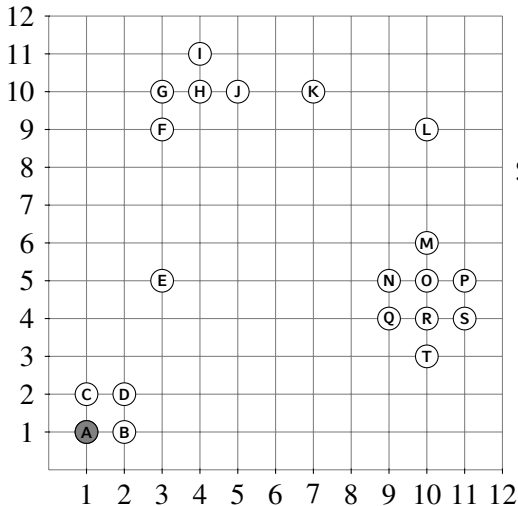
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

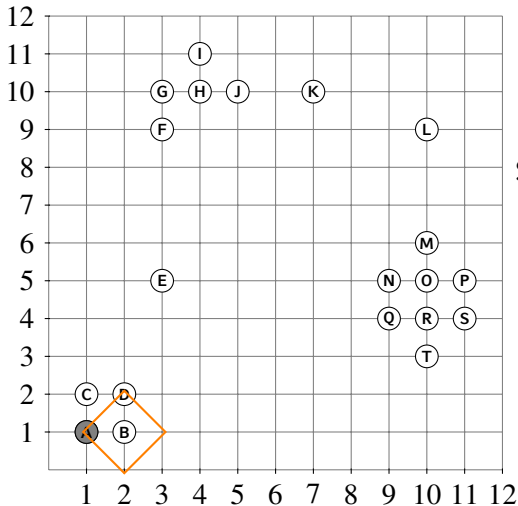
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

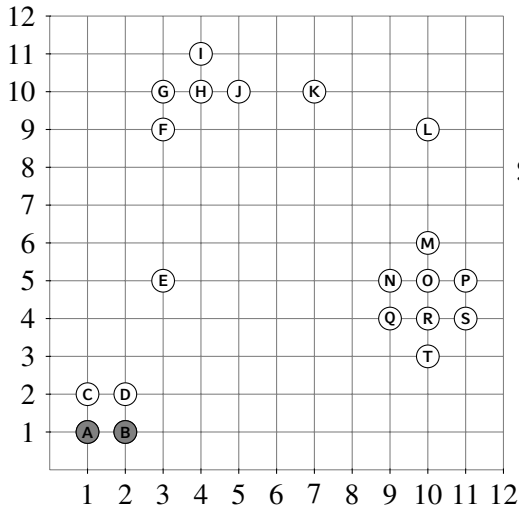
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

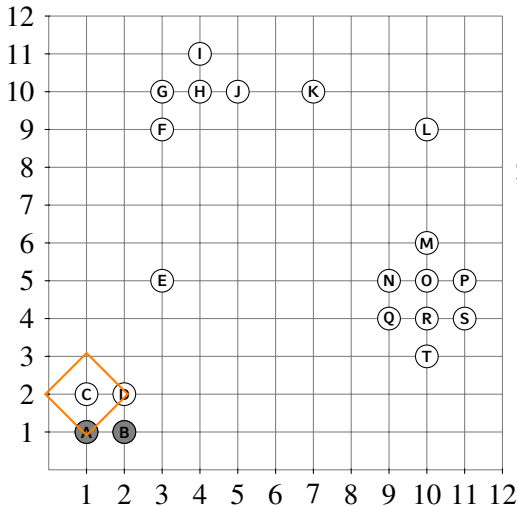
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

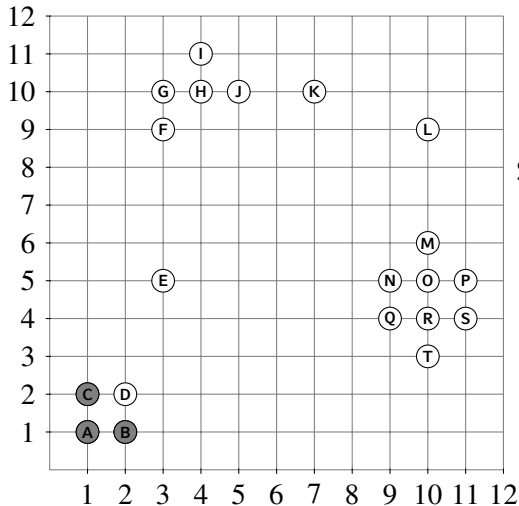
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

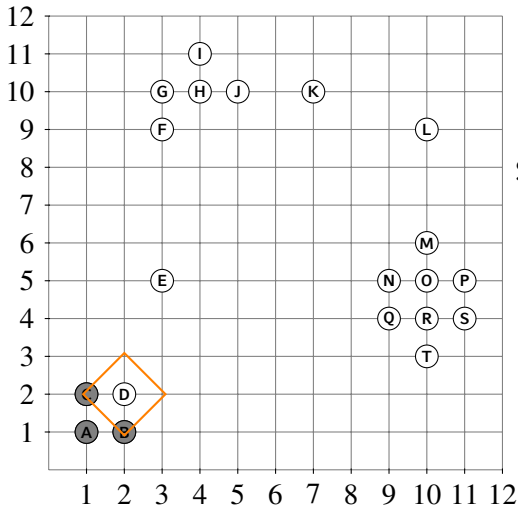
Seed list:



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$\text{minPts} = 4$

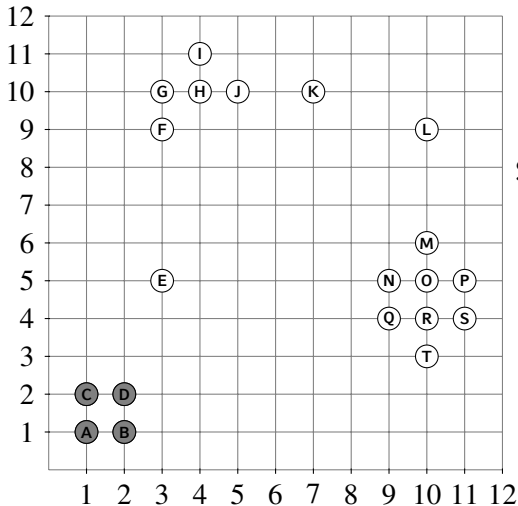
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

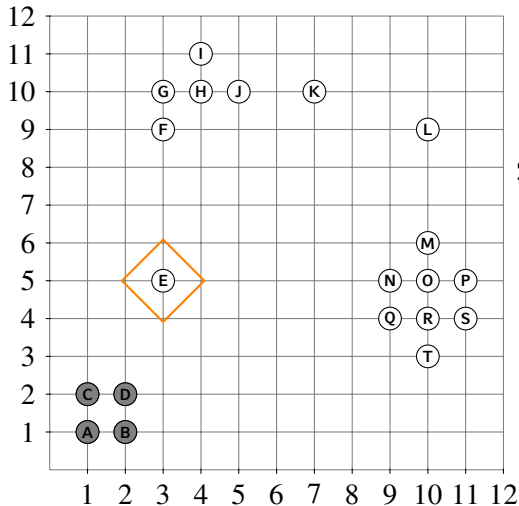
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

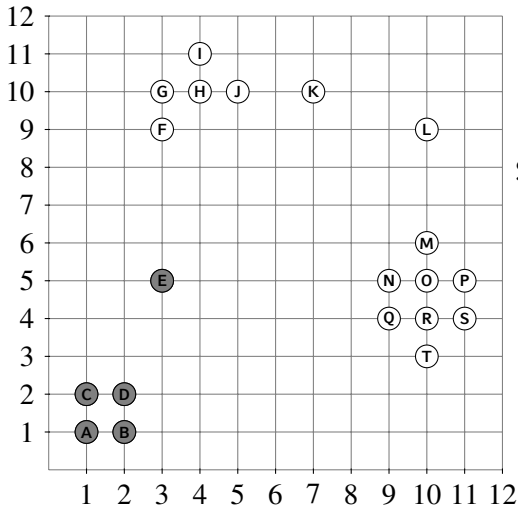
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

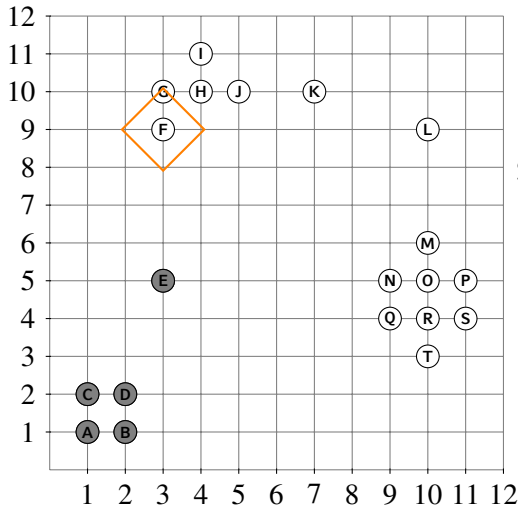
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

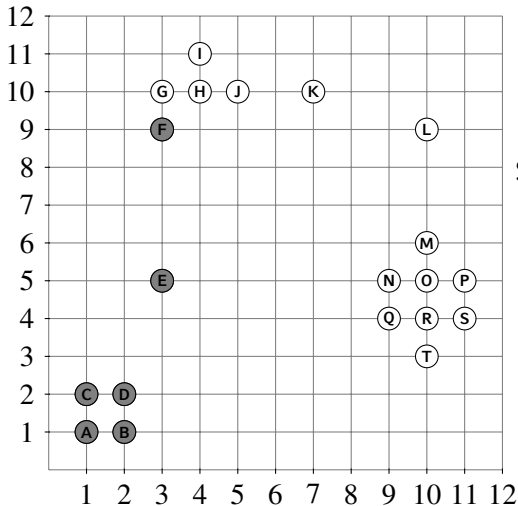
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

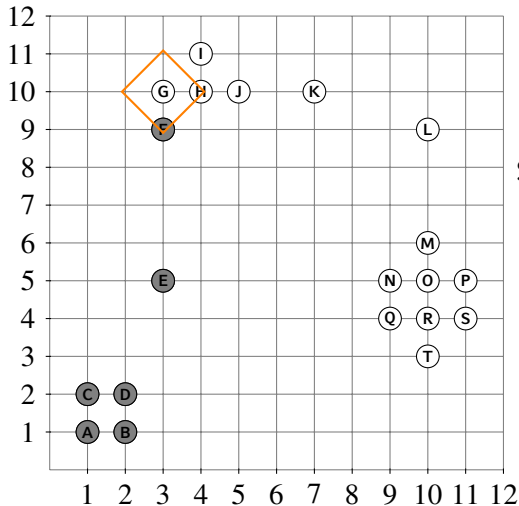
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

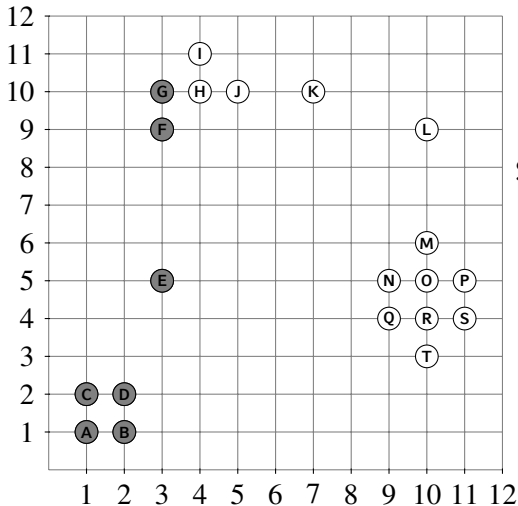
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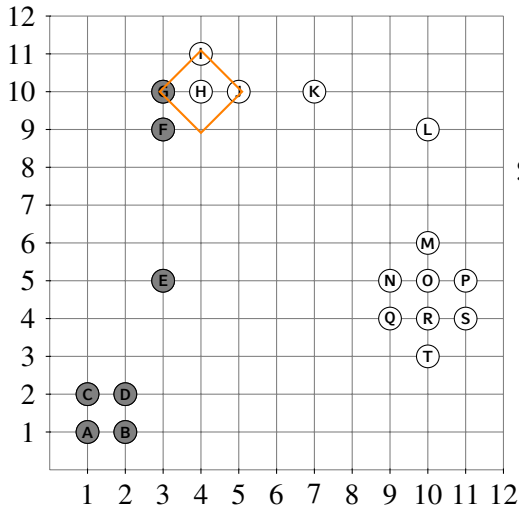
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

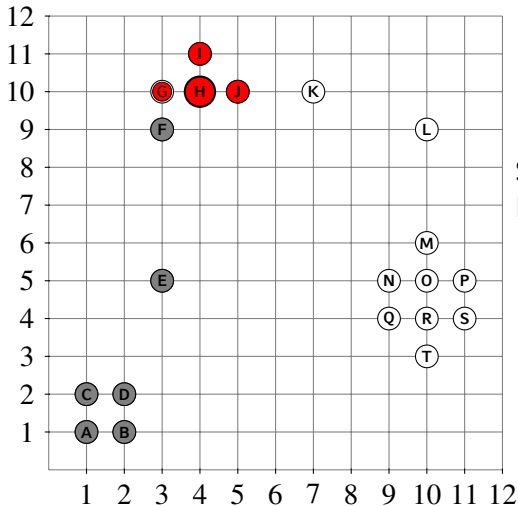
Seed list:



$\epsilon = 1.1$

$\text{minPts} = 4$

Seed list:

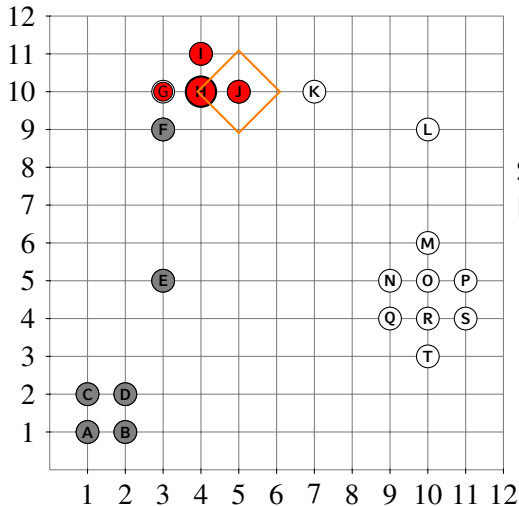


$\varepsilon = 1.1$

$\text{minPts} = 4$

Seed list:

IJ

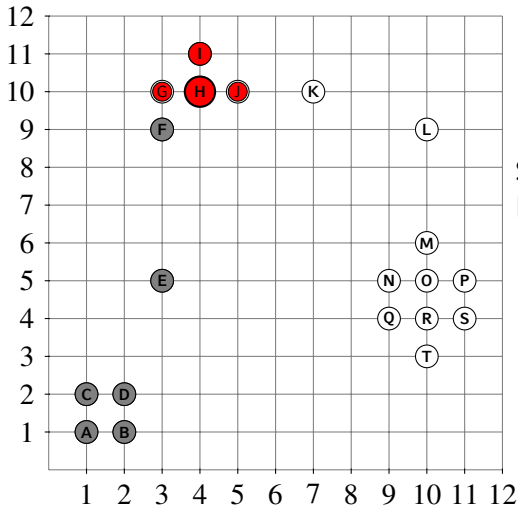


$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

Seed list:

I

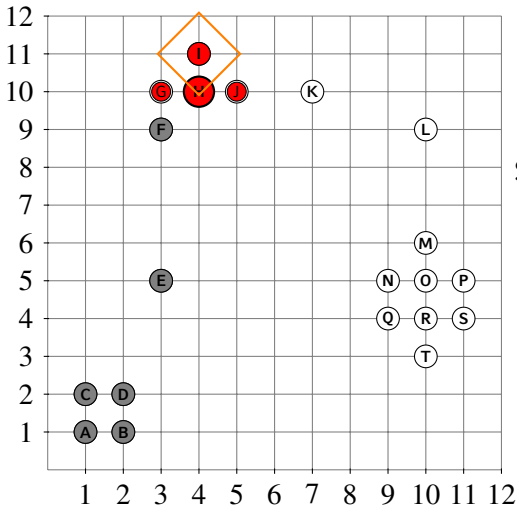


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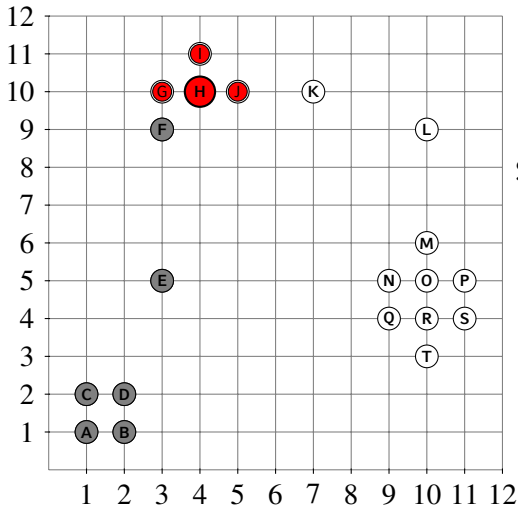
$$\text{minPts} = 4$$

Seed list:

I


$$\varepsilon = 1.1$$
$$\text{minPts} = 4$$

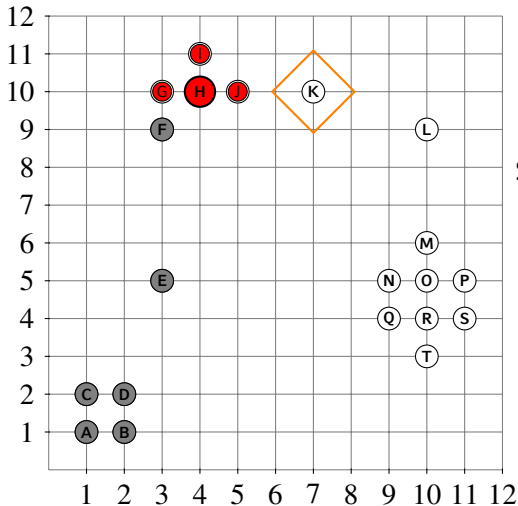
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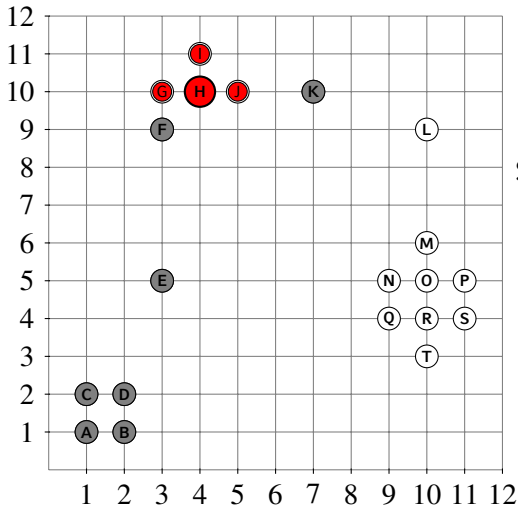
$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

Seed list:


$$\varepsilon = 1.1$$
$$minPts = 4$$

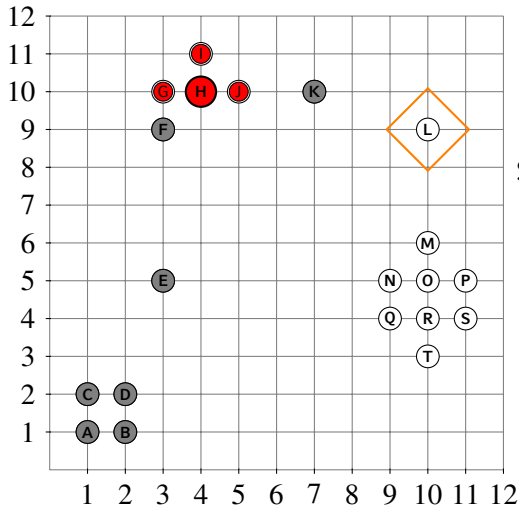
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

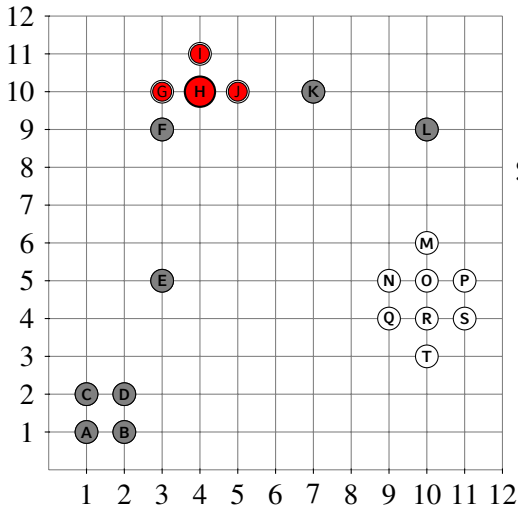
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

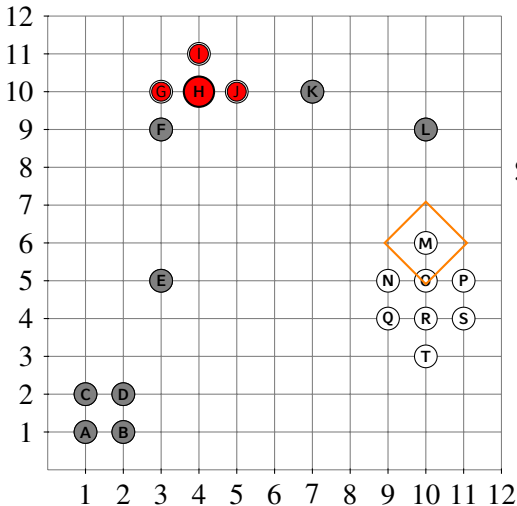
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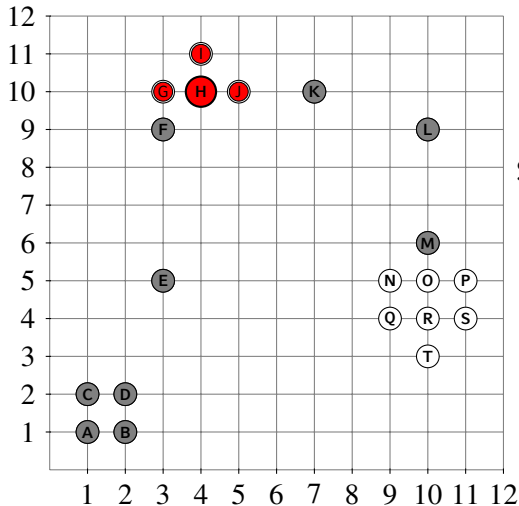
$\varepsilon = 1.1$

$\text{minPts} = 4$

Seed list:


$$\varepsilon = 1.1$$
$$\text{minPts} = 4$$

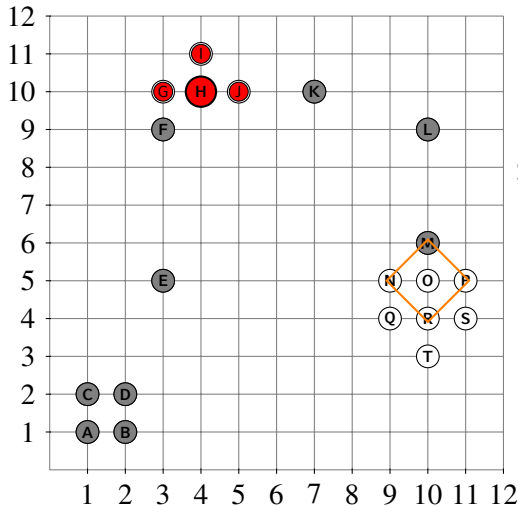
Seed list:



$\varepsilon = 1.1$

$\text{minPts} = 4$

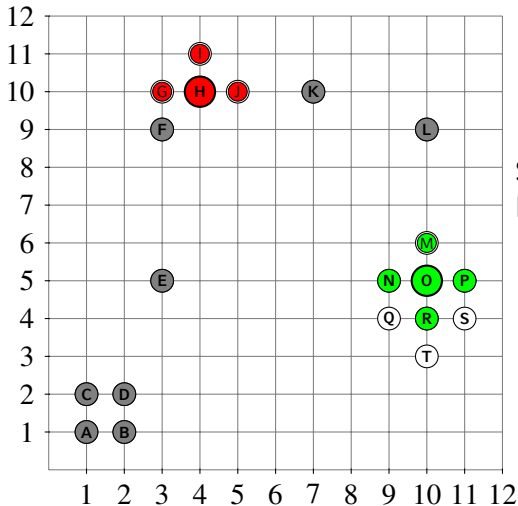
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

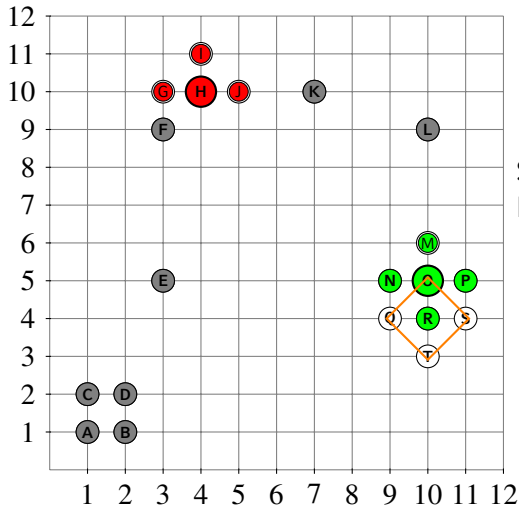
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

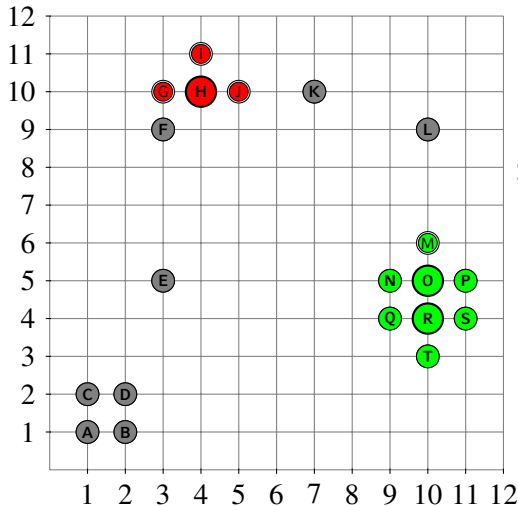
Seed list:
NPR



$\epsilon = 1.1$

$\text{minPts} = 4$

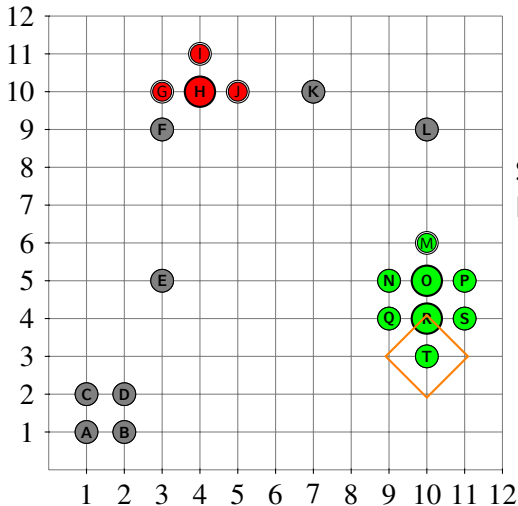
Seed list:
NP



$\varepsilon = 1.1$

$\text{minPts} = 4$

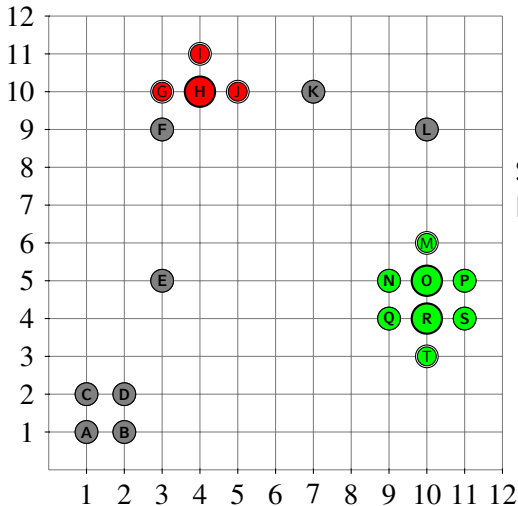
Seed list:
NPQST



$\varepsilon = 1.1$

$\text{minPts} = 4$

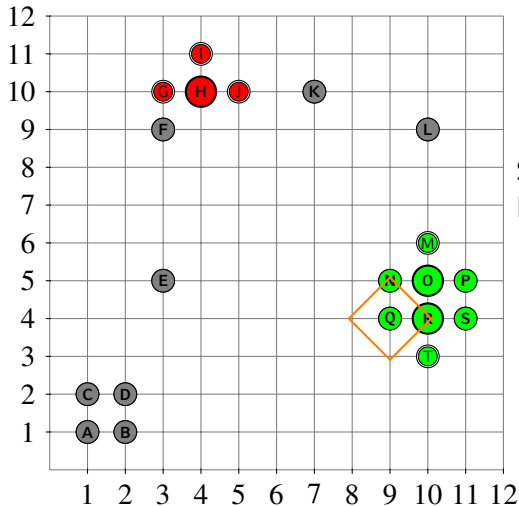
Seed list:
NPQS



$\varepsilon = 1.1$

$\text{minPts} = 4$

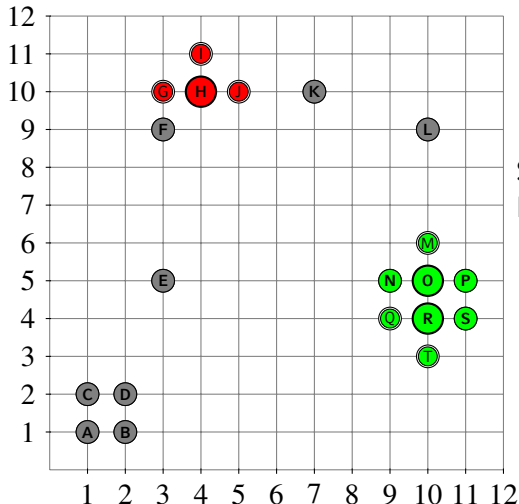
Seed list:
NPQS



$\epsilon = 1.1$

$\text{minPts} = 4$

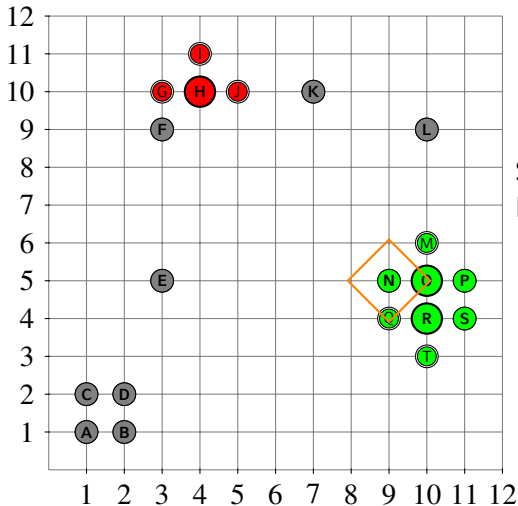
Seed list:
NPS



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

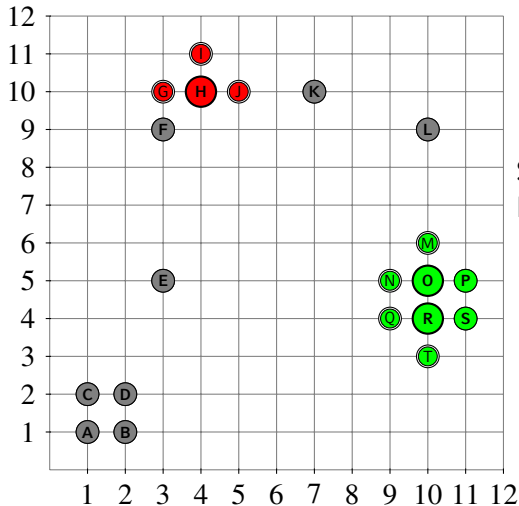
Seed list:
NPS



$\epsilon = 1.1$

$\text{minPts} = 4$

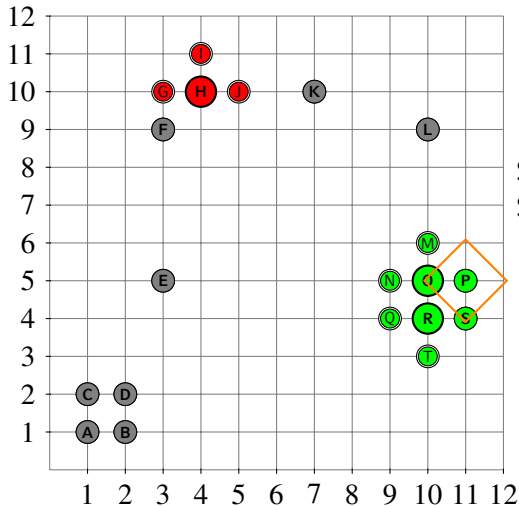
Seed list:
PS



$\varepsilon = 1.1$

$\text{minPts} = 4$

Seed list:
PS

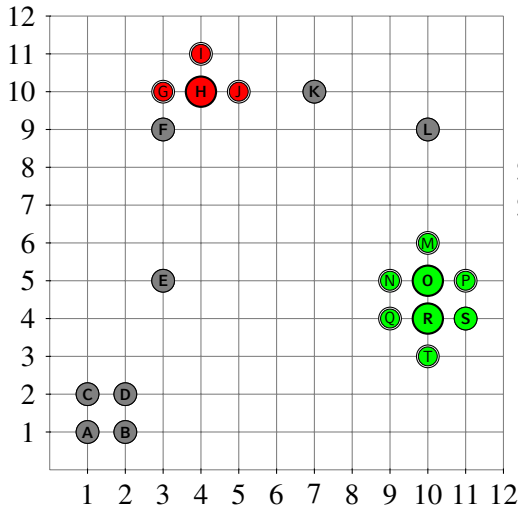


$\epsilon = 1.1$

$\text{minPts} = 4$

Seed list:

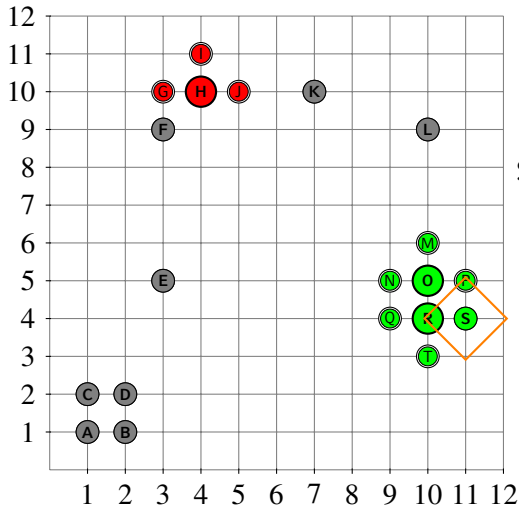
S



$\varepsilon = 1.1$

$\text{minPts} = 4$

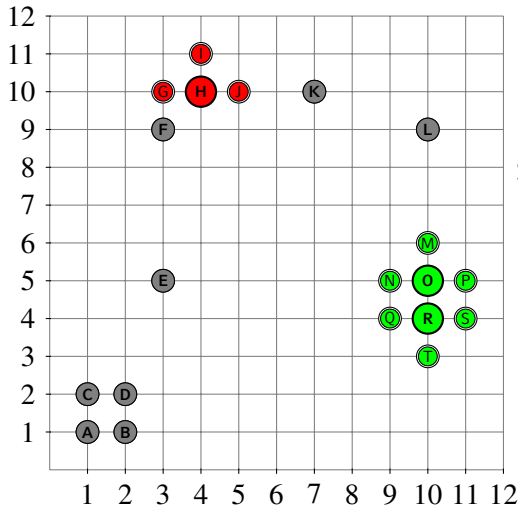
Seed list:
S



$\epsilon = 1.1$

$\text{minPts} = 4$

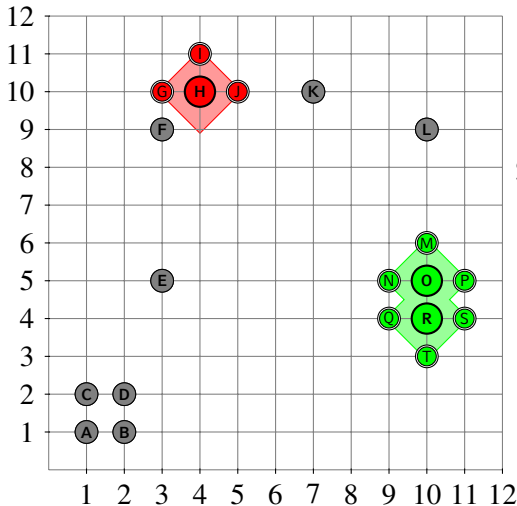
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

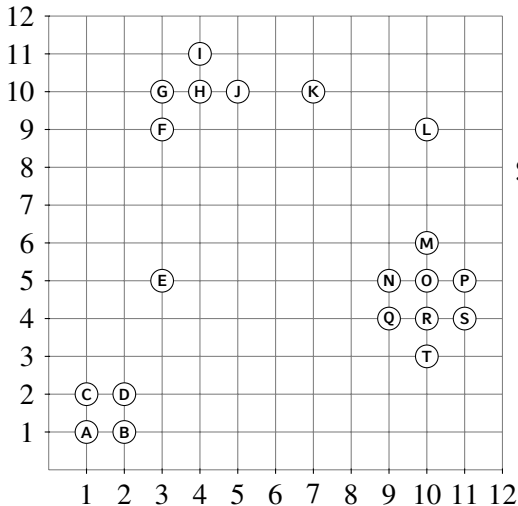
Seed list:



$$\varepsilon = 1.1$$

$$\text{minPts} = 4$$

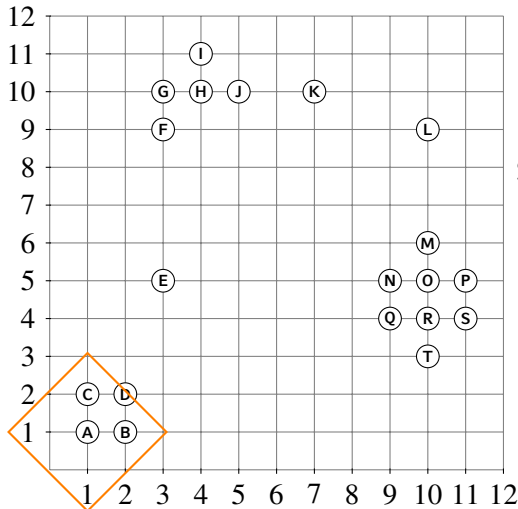
Seed list:



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

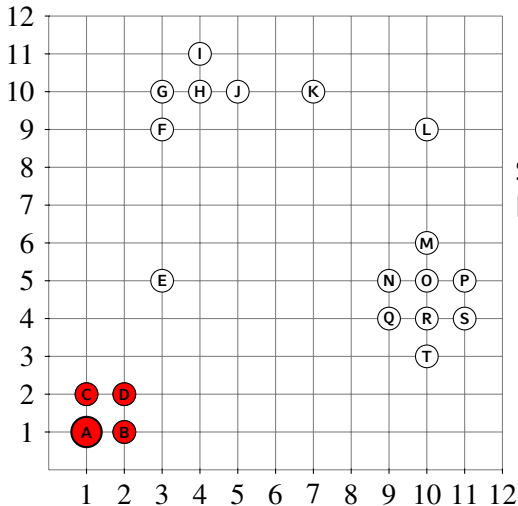
Seed list:



$\varepsilon = 2.1$

$\text{minPts} = 4$

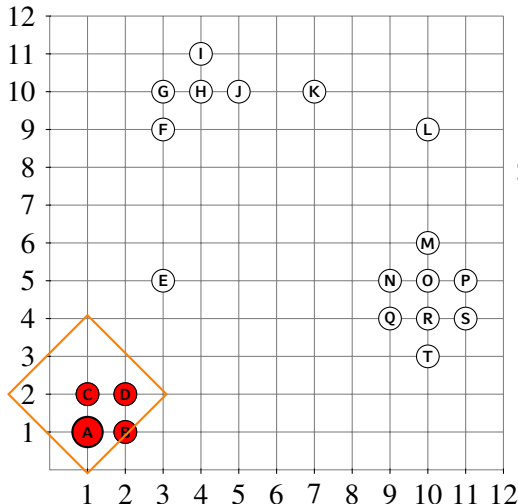
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

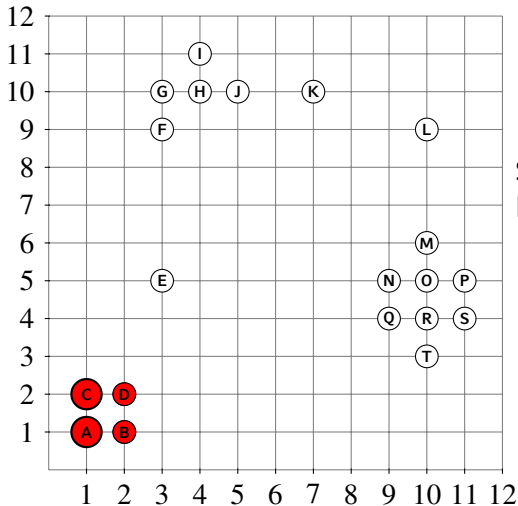
Seed list:
BCD



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

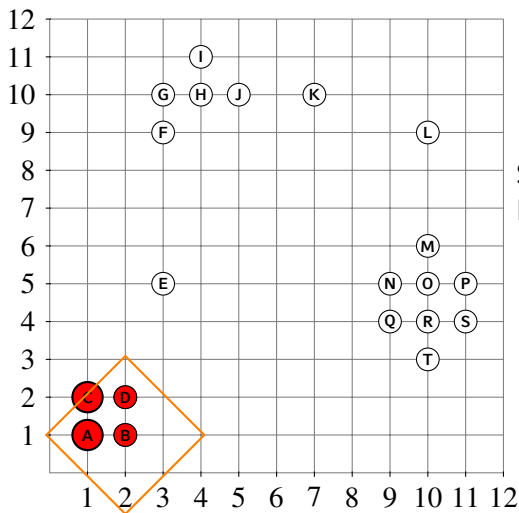
Seed list:
BD



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

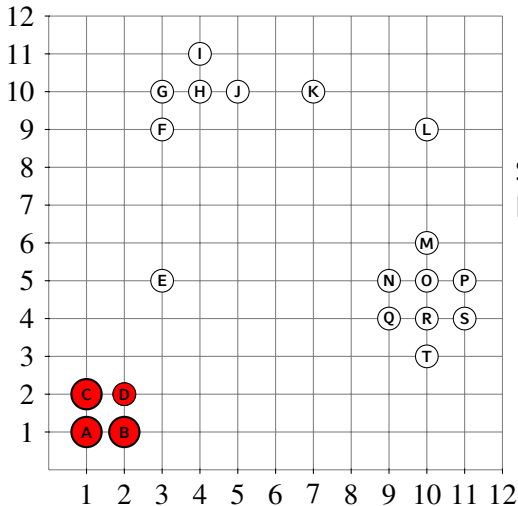
Seed list:
BD



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

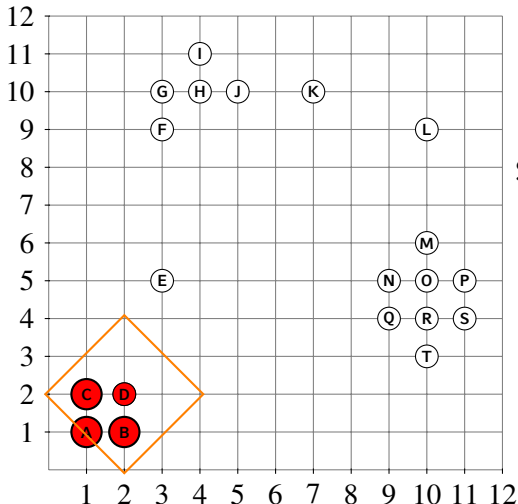
Seed list:
D



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

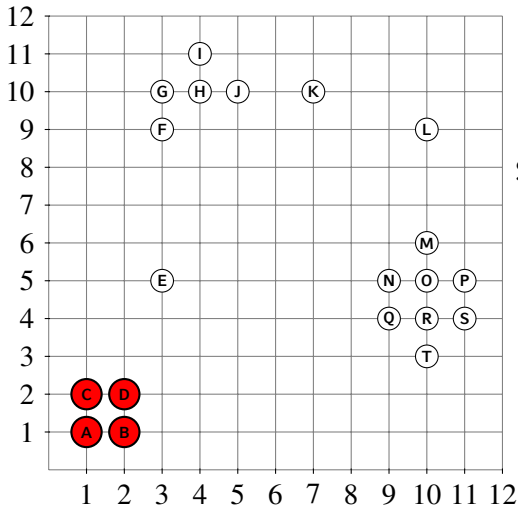
Seed list:
D



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

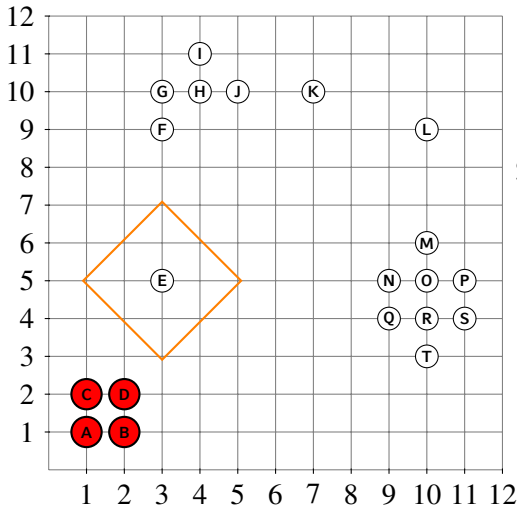
Seed list:



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

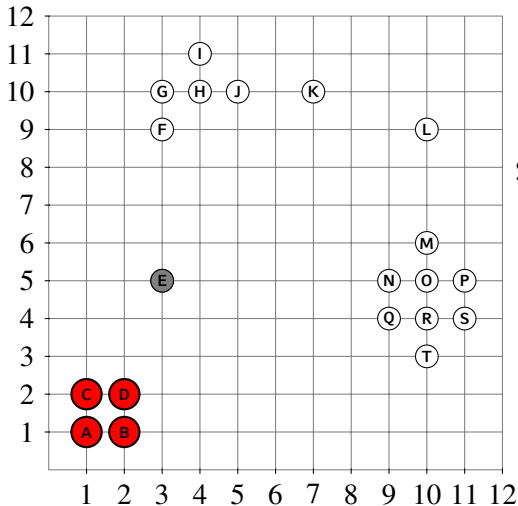
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

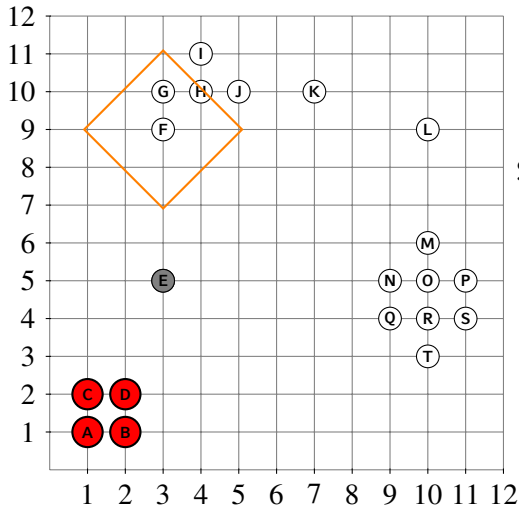
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

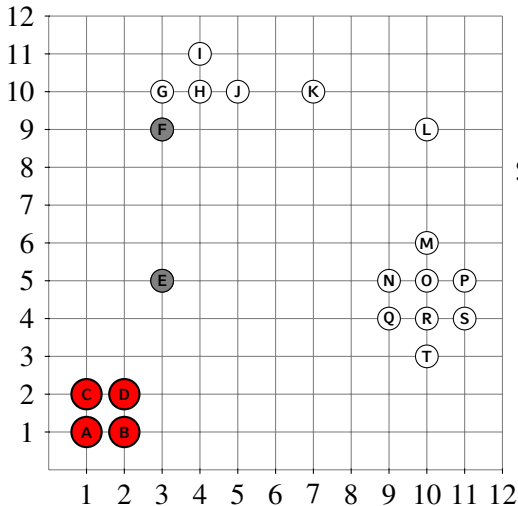
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

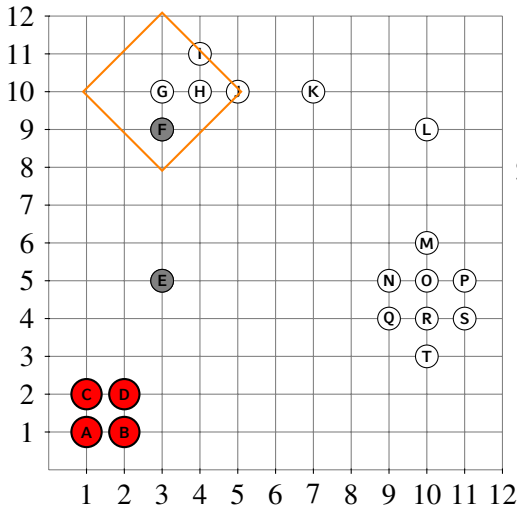
Seed list:



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

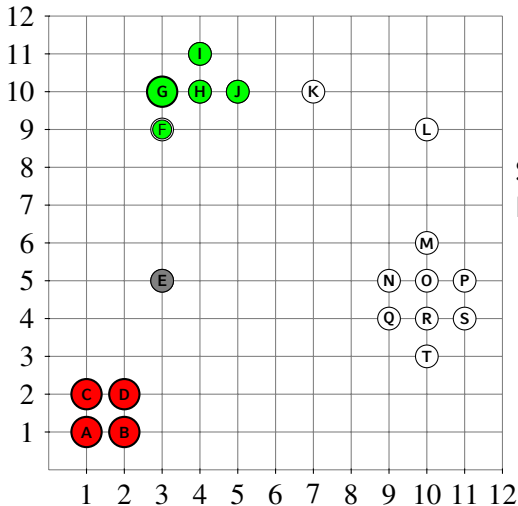
Seed list:



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

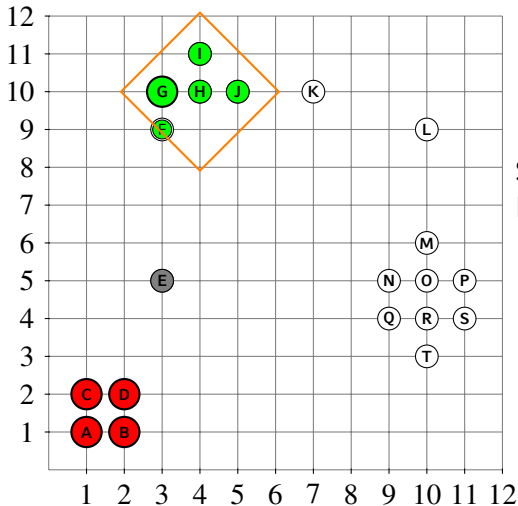
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

Seed list:
HIJ

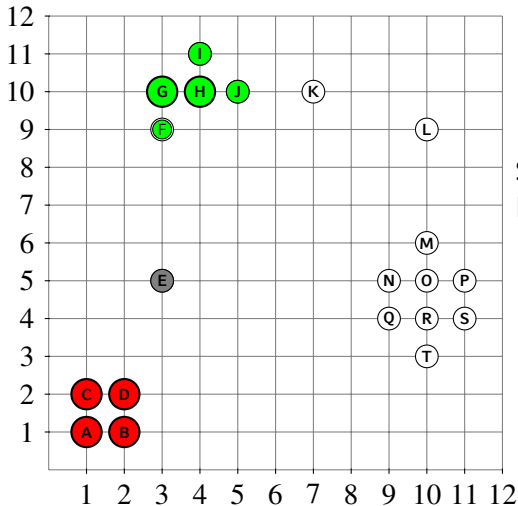


$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

Seed list:

IJ

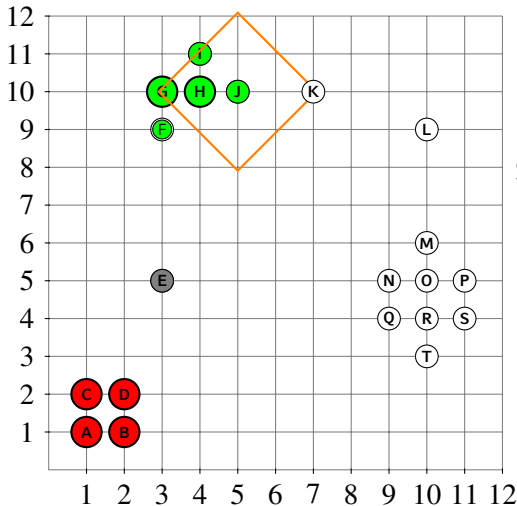


$\varepsilon = 2.1$

$\text{minPts} = 4$

Seed list:

IJ

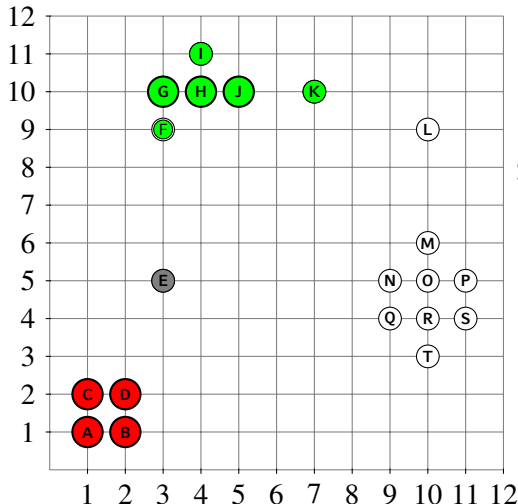


$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

Seed list:

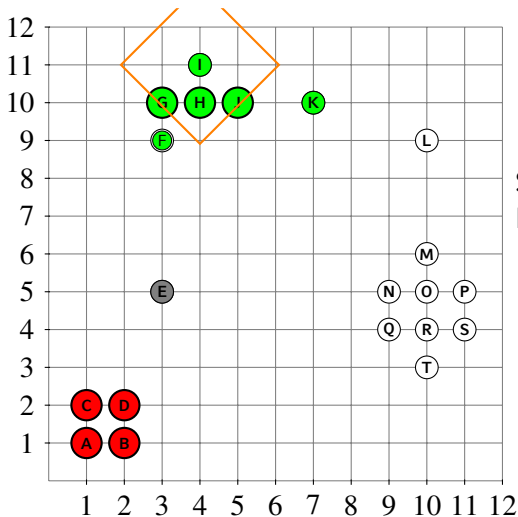
1



$\epsilon = 2.1$

$\text{minPts} = 4$

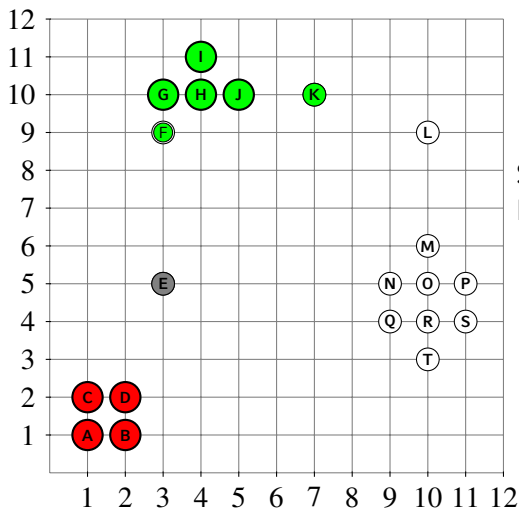
Seed list:
IK



$\varepsilon = 2.1$

$\text{minPts} = 4$

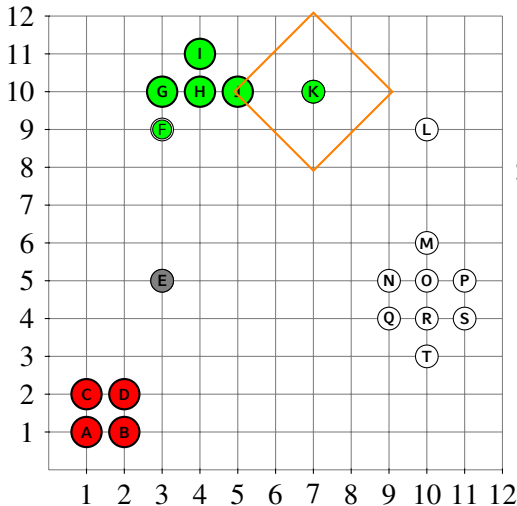
Seed list:
K



$\epsilon = 2.1$

$\text{minPts} = 4$

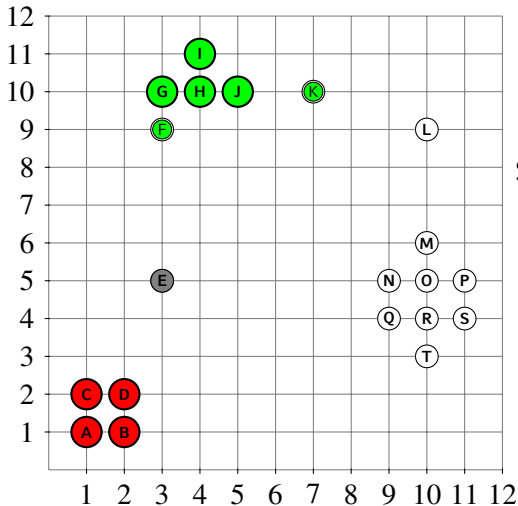
Seed list:
K



$$\epsilon = 2.1$$

$$\text{minPts} = 4$$

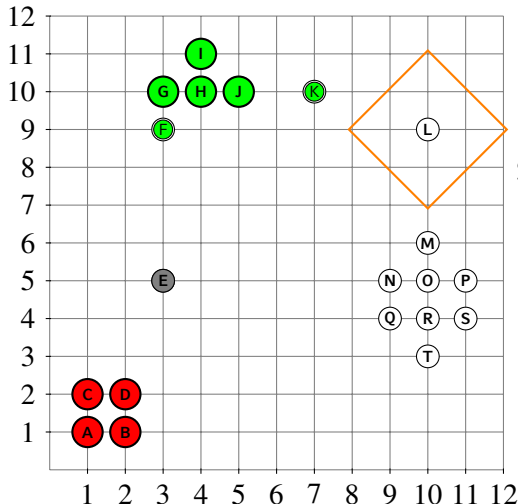
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

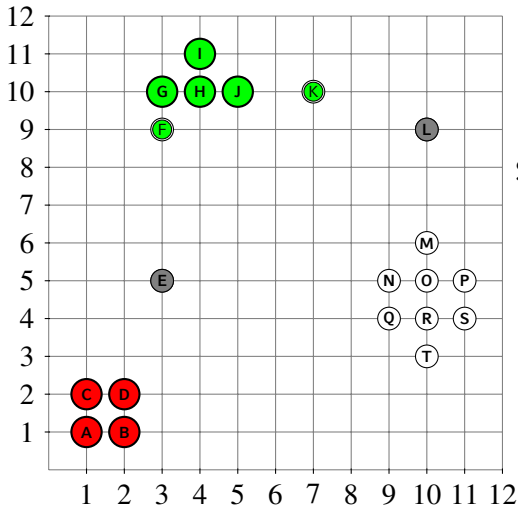
Seed list:



$\varepsilon = 2.1$

$\text{minPts} = 4$

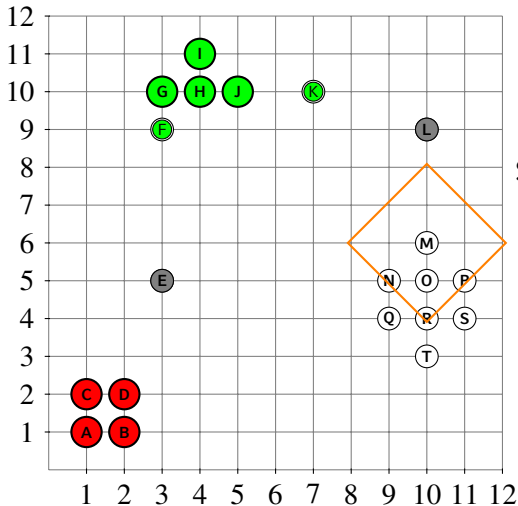
Seed list:



$$\varepsilon = 2.1$$

$$\text{minPts} = 4$$

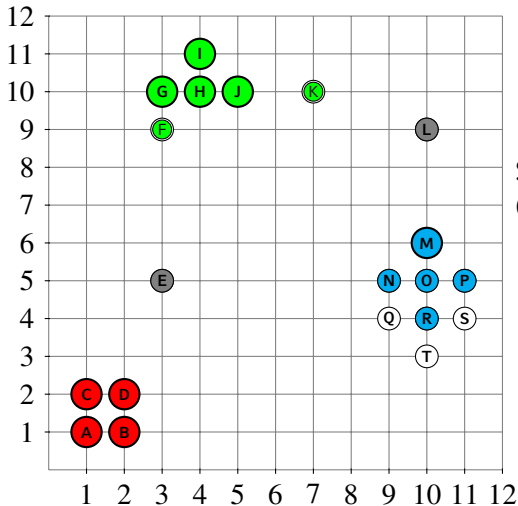
Seed list:



$\varepsilon = 2.1$

$\text{minPts} = 4$

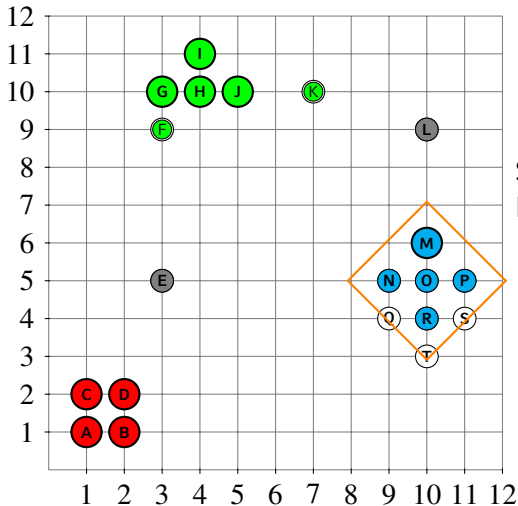
Seed list:



$\epsilon = 2.1$

$\text{minPts} = 4$

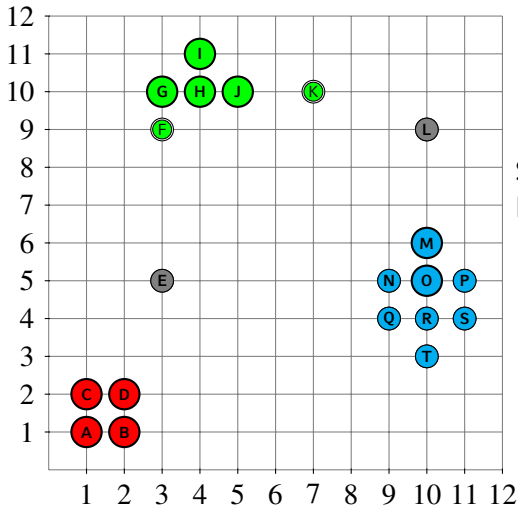
Seed list:
ONPR



$\epsilon = 2.1$

$\text{minPts} = 4$

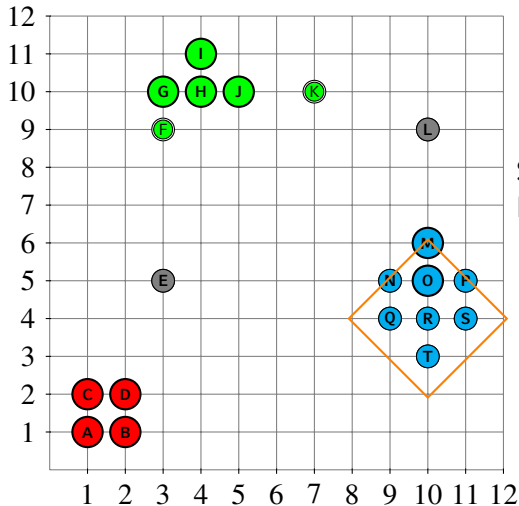
Seed list:
NPR



$\varepsilon = 2.1$

$\text{minPts} = 4$

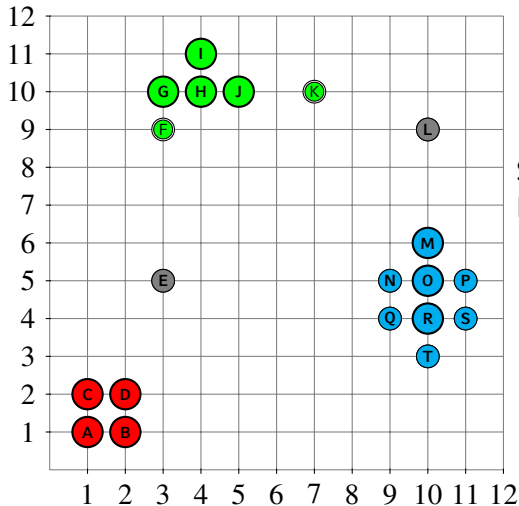
Seed list:
NPRQST



$\epsilon = 2.1$

$\text{minPts} = 4$

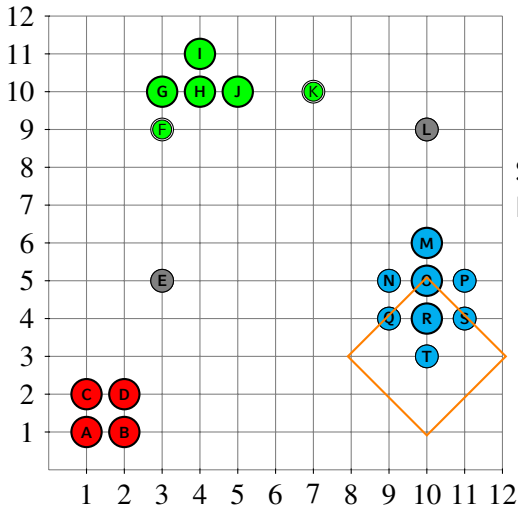
Seed list:
NPQST



$\epsilon = 2.1$

$\text{minPts} = 4$

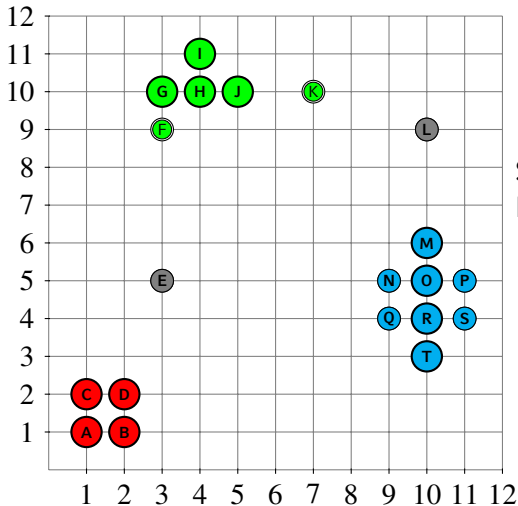
Seed list:
NPQST



$\epsilon = 2.1$

$\text{minPts} = 4$

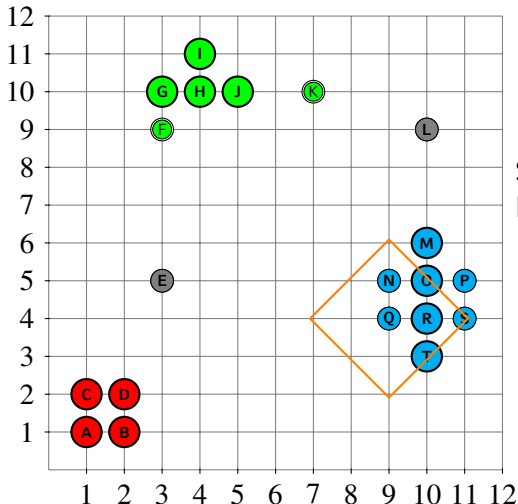
Seed list:
NPQS



$\varepsilon = 2.1$

$\text{minPts} = 4$

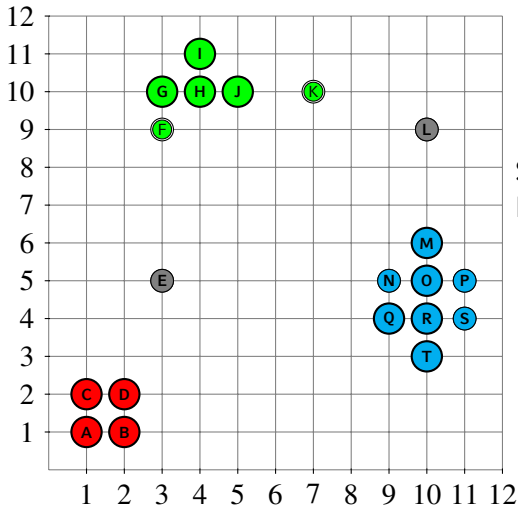
Seed list:
NPQS



$\varepsilon = 2.1$

$\text{minPts} = 4$

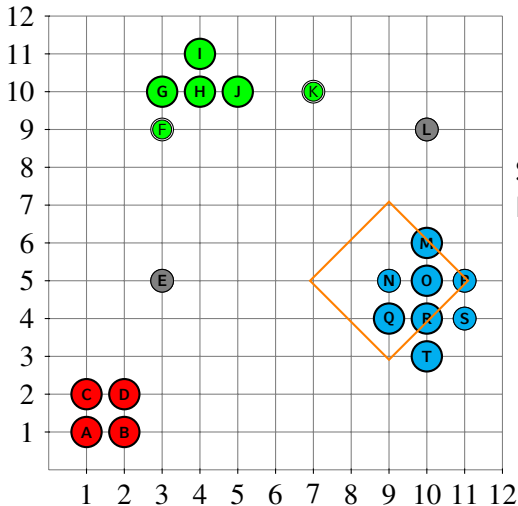
Seed list:
NPS



$\varepsilon = 2.1$

$\text{minPts} = 4$

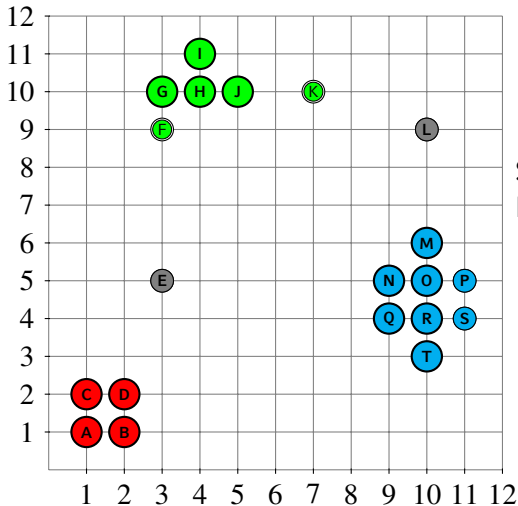
Seed list:
NPS



$\epsilon = 2.1$

$\text{minPts} = 4$

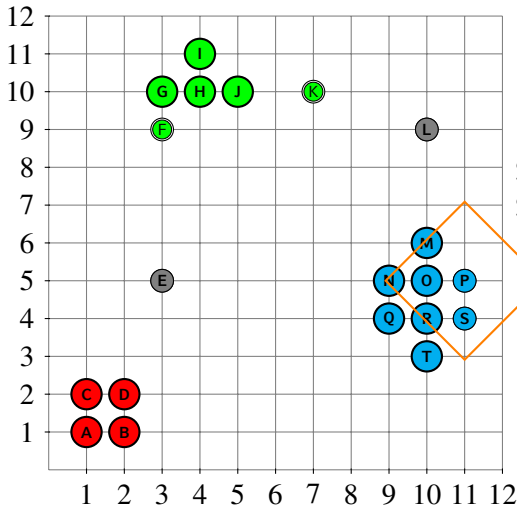
Seed list:
PS



$\epsilon = 2.1$

$\text{minPts} = 4$

Seed list:
PS

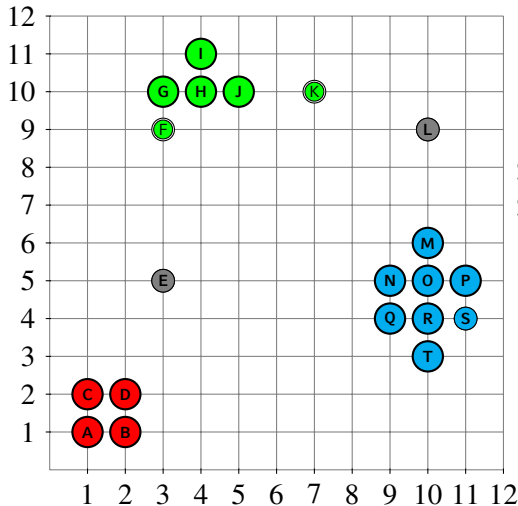


$\epsilon = 2.1$

$\text{minPts} = 4$

Seed list:

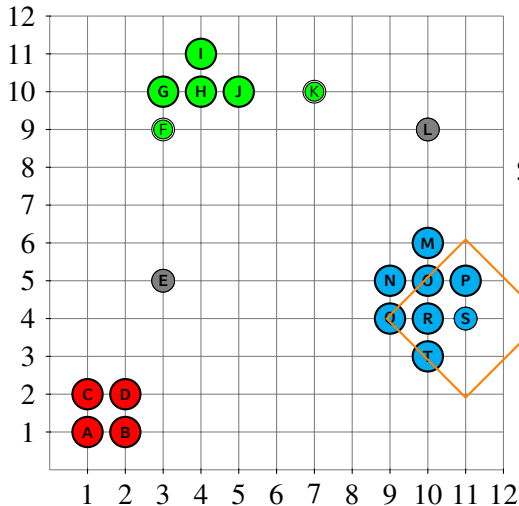
S



$\varepsilon = 2.1$

$\text{minPts} = 4$

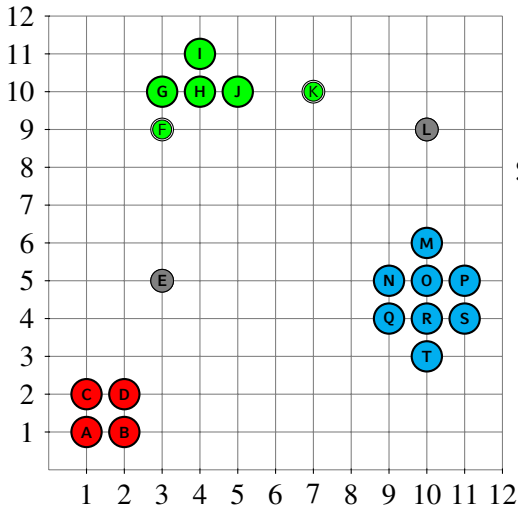
Seed list:
S



$\varepsilon = 2.1$

$\text{minPts} = 4$

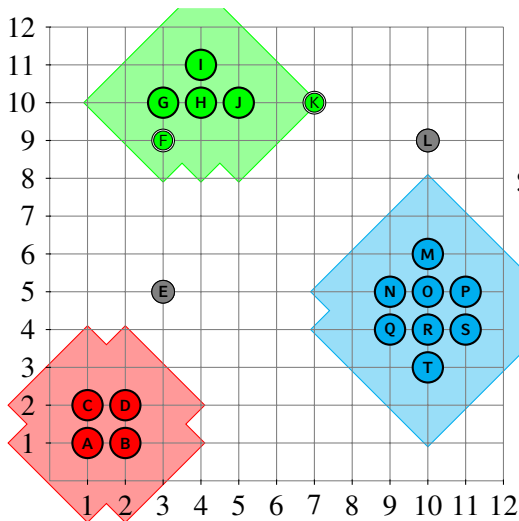
Seed list:



$\varepsilon = 2.1$

$\text{minPts} = 4$

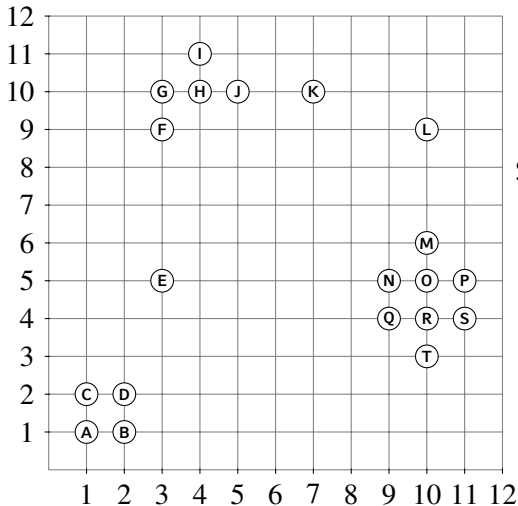
Seed list:



$\epsilon = 2.1$

$\text{minPts} = 4$

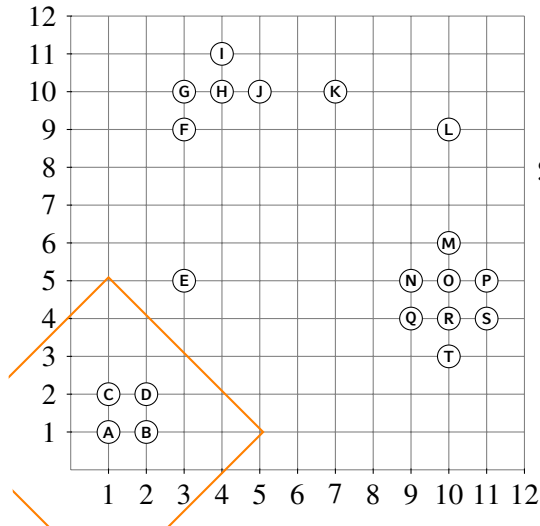
Seed list:



$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

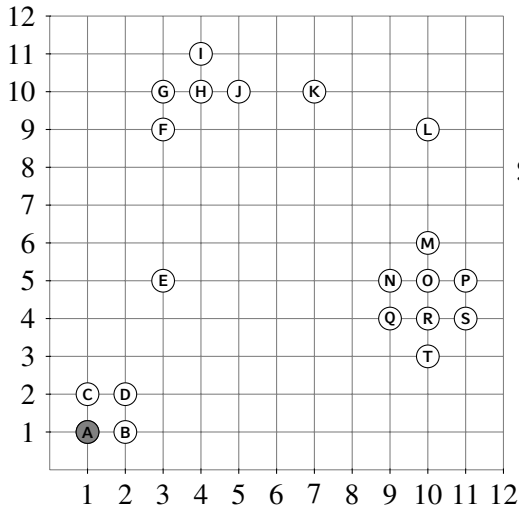
Seed list:



$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

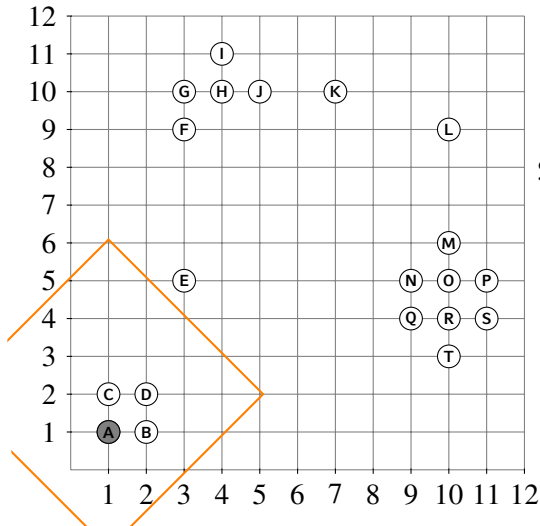
Seed list:



$\epsilon = 4.1$

$\text{minPts} = 5$

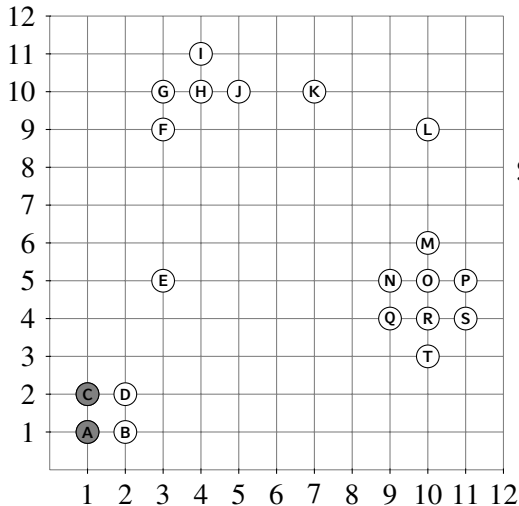
Seed list:



$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

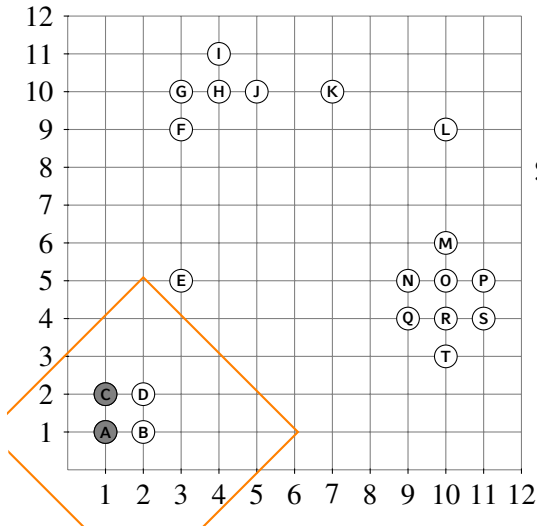
Seed list:



$\epsilon = 4.1$

$\text{minPts} = 5$

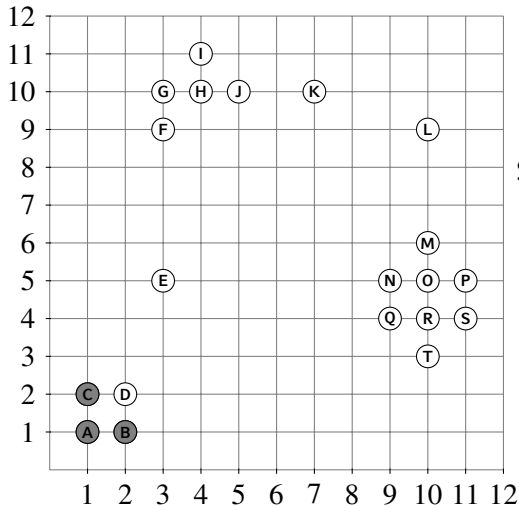
Seed list:



$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

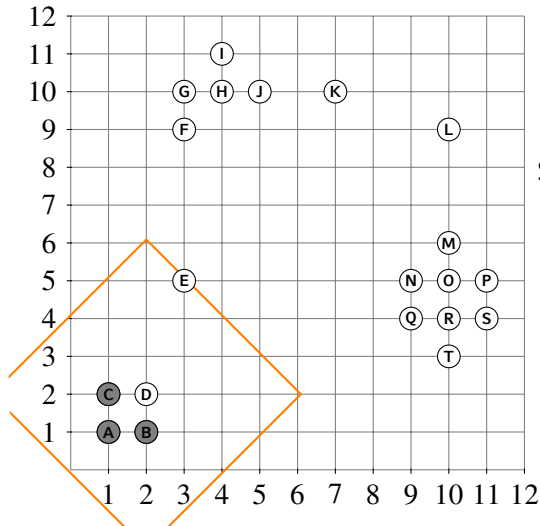
Seed list:



$\epsilon = 4.1$

$\text{minPts} = 5$

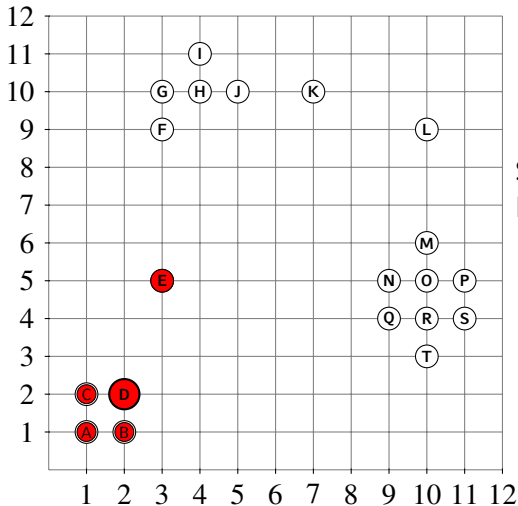
Seed list:



$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

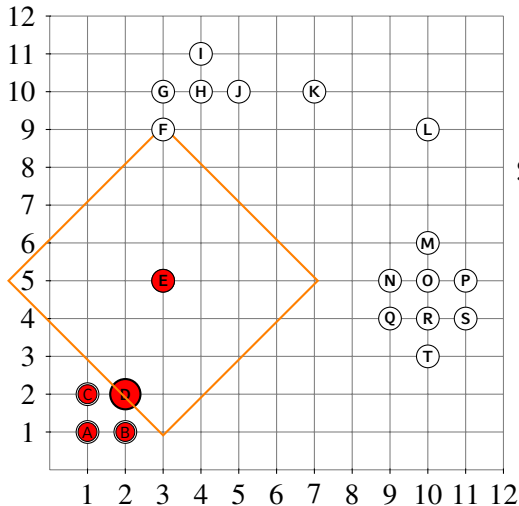


$\varepsilon = 4.1$

$\text{minPts} = 5$

Seed list:

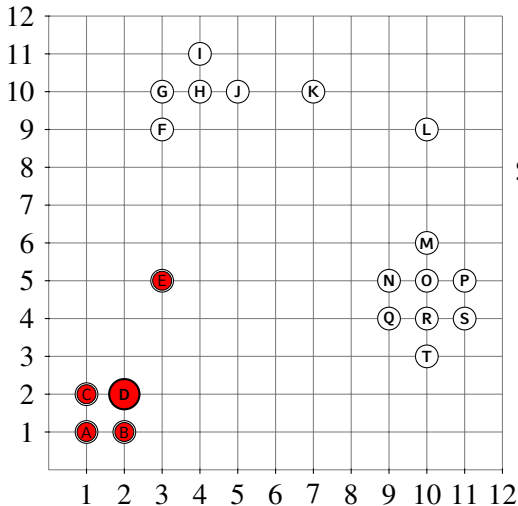
E



$\varepsilon = 4.1$

$\text{minPts} = 5$

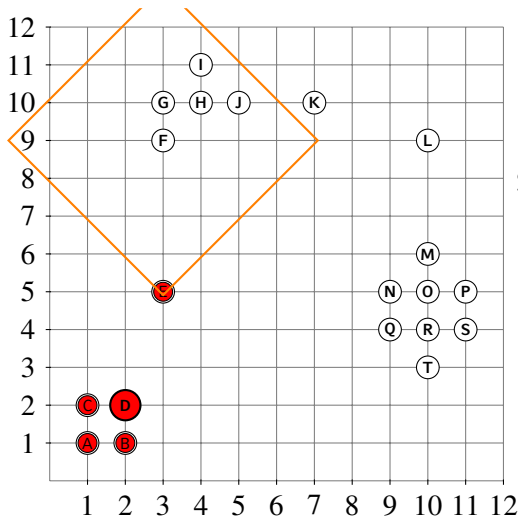
Seed list:



$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

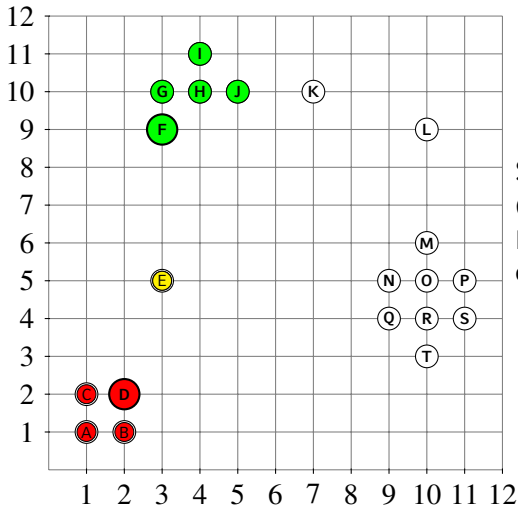
Seed list:



$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:



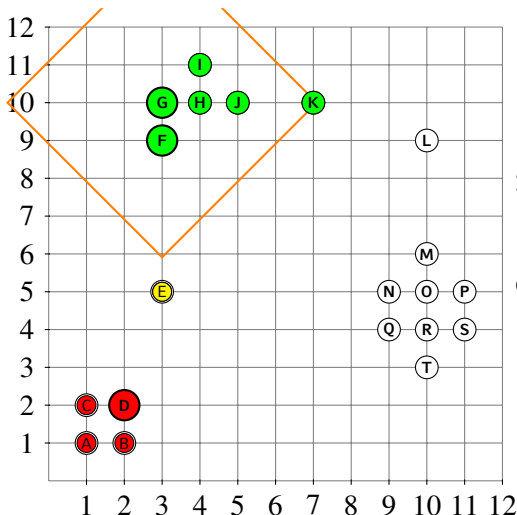
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

GHIJ

E nicht
eindeutig!



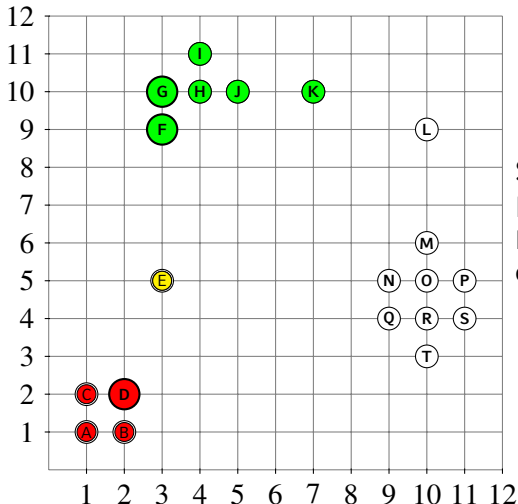
$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

HIJ

E nicht
eindeutig!



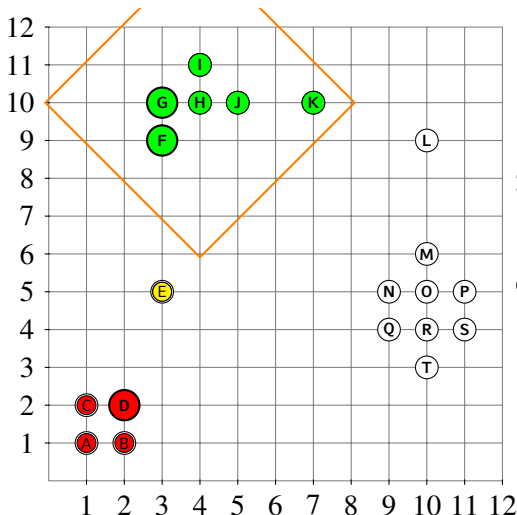
$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

HIJK

E nicht
eindeutig!



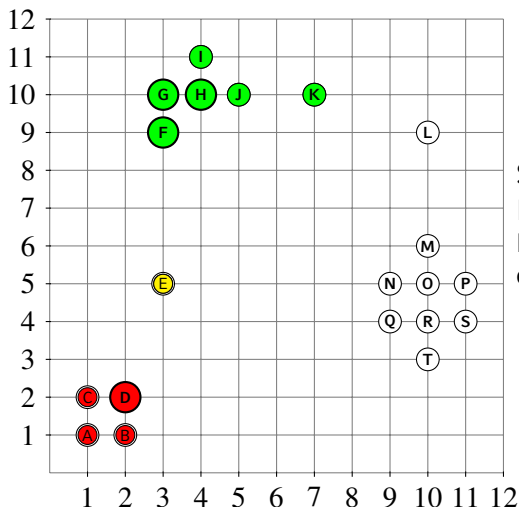
$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

IJK

E nicht
eindeutig!



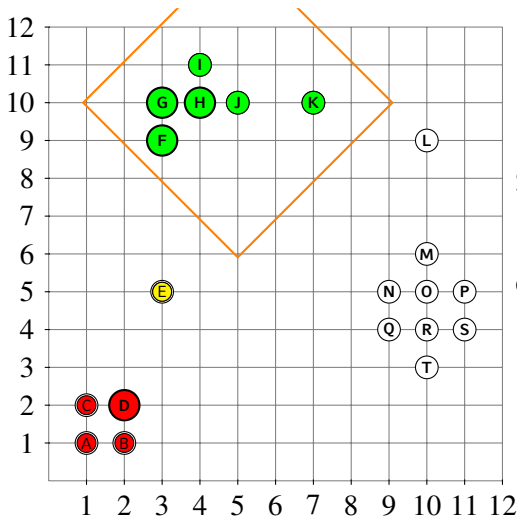
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

IJK

E nicht
eindeutig!



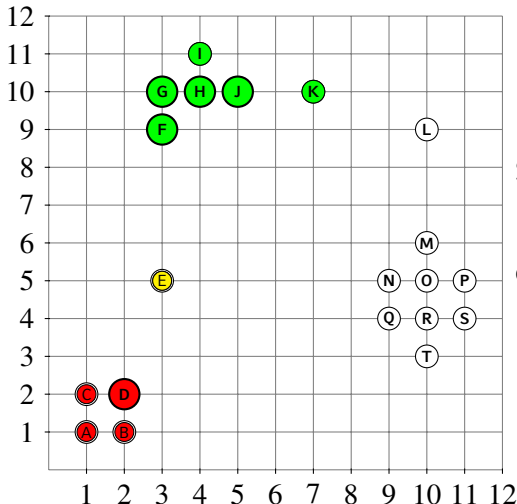
$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

IK

E nicht
eindeutig!



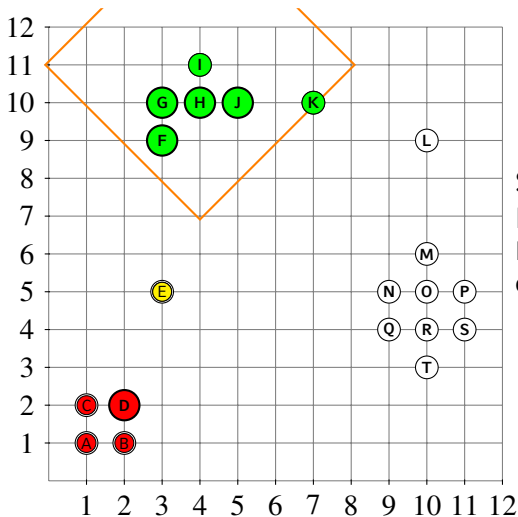
$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

IK

E nicht
eindeutig!



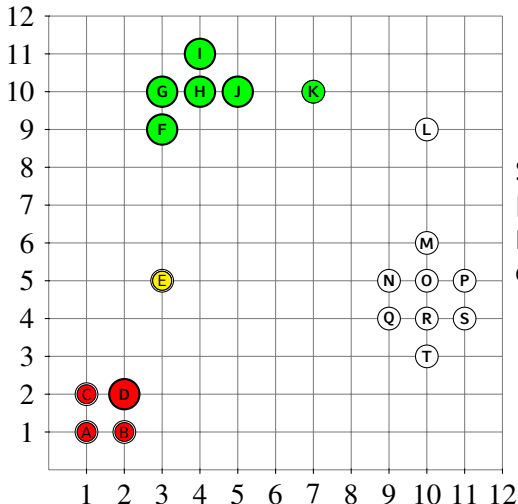
$$\epsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

K

E nicht
eindeutig!



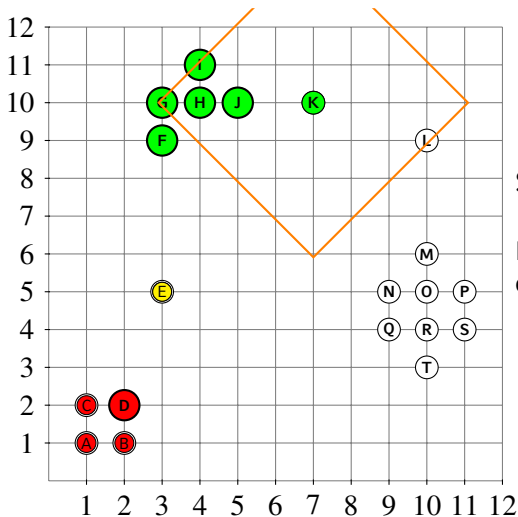
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

K

E nicht
eindeutig!

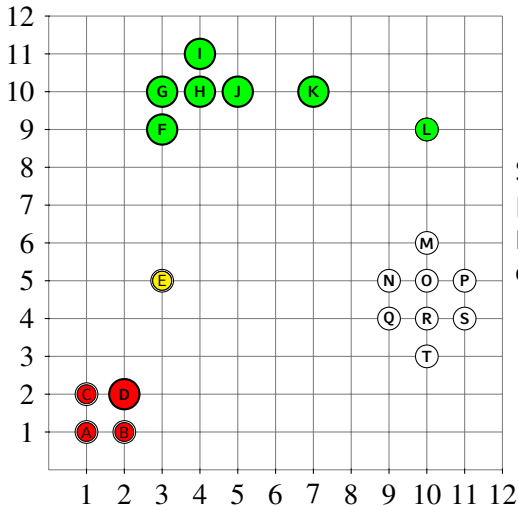


$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

E nicht
eindeutig!

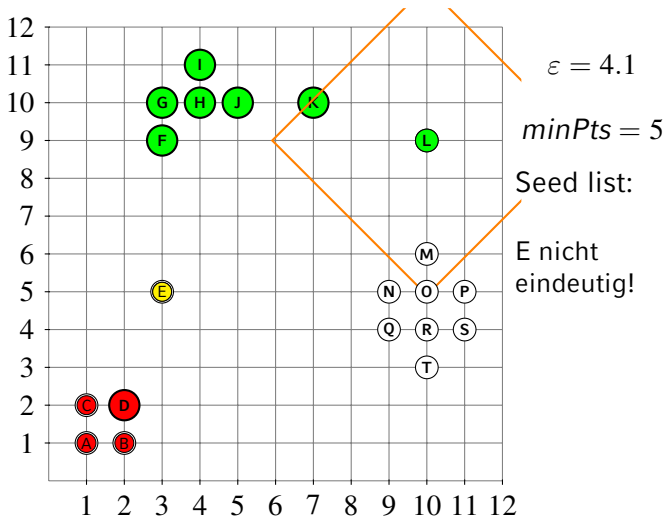


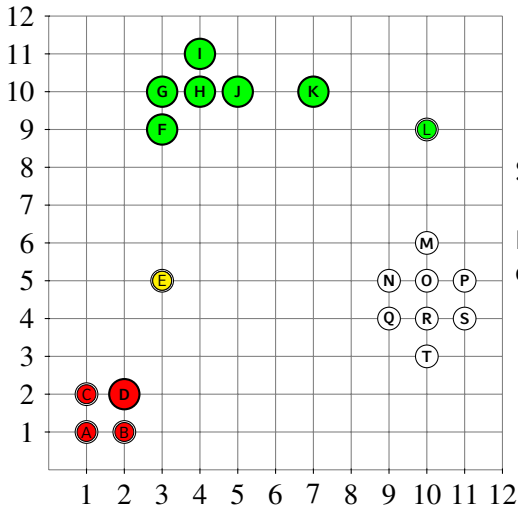
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

L
E nicht
eindeutig!



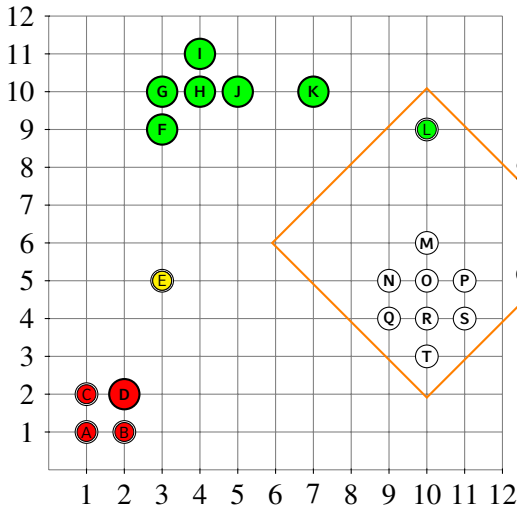


$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

E nicht
eindeutig!

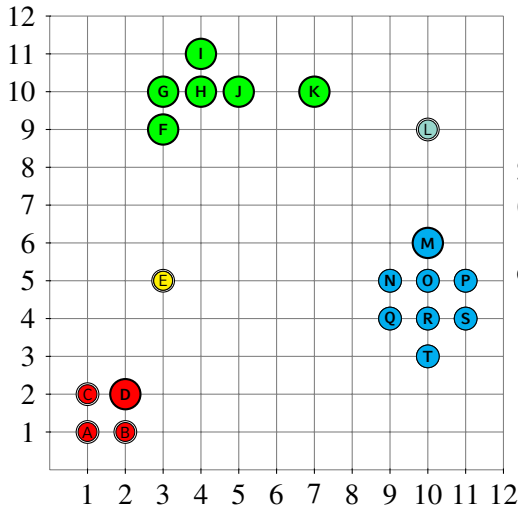


$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

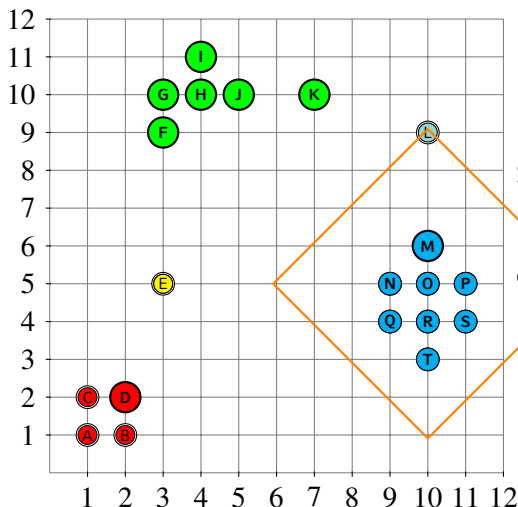
E nicht
eindeutig!



$\epsilon = 4.1$

$\text{minPts} = 5$

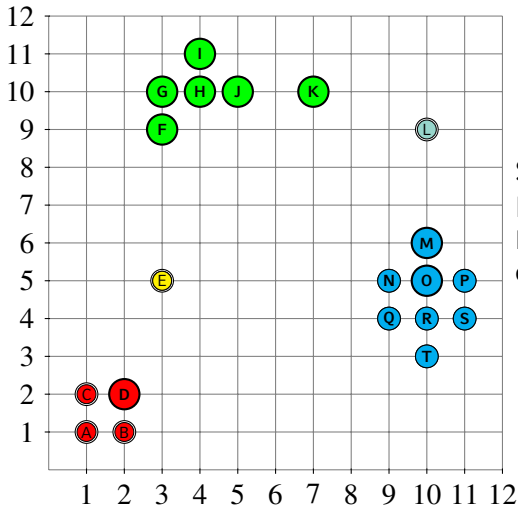
Seed list:
ONPRQST
E und L nicht
eindeutig!



$\epsilon = 4.1$

$\text{minPts} = 5$

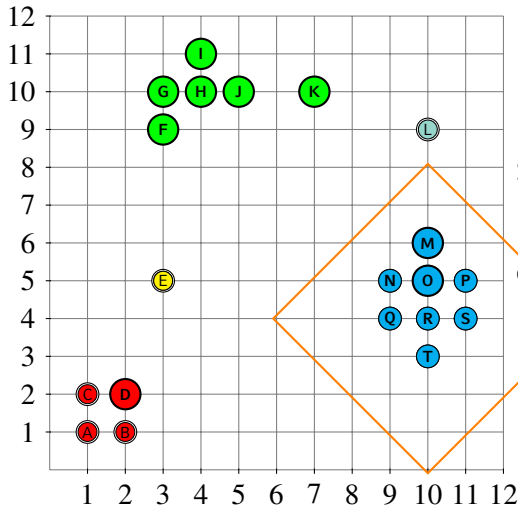
Seed list:
NPQST
E und L nicht
eindeutig!



$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

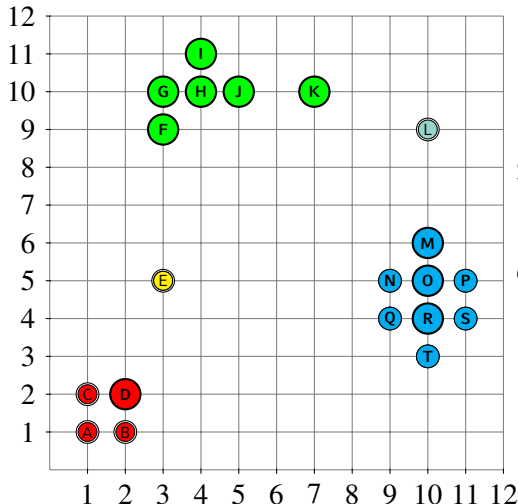
Seed list:
NPQST
E und L nicht
eindeutig!



$\epsilon = 4.1$

$\text{minPts} = 5$

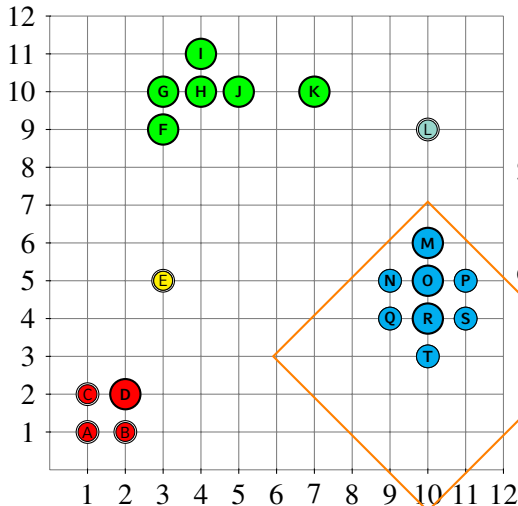
Seed list:
NPQST
E und L nicht
eindeutig!



$\varepsilon = 4.1$

$\text{minPts} = 5$

Seed list:
NPQST
E und L nicht
eindeutig!



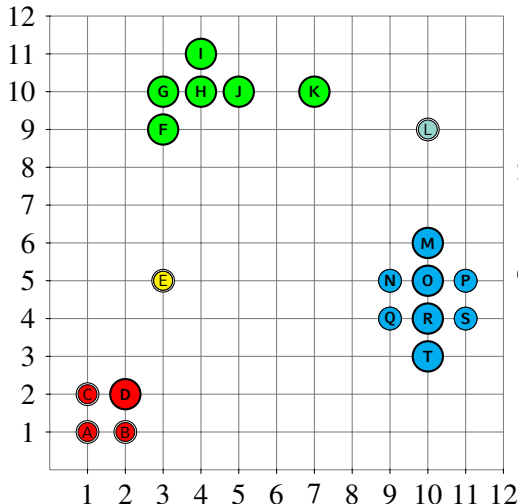
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

NPQS

E und L nicht
eindeutig!



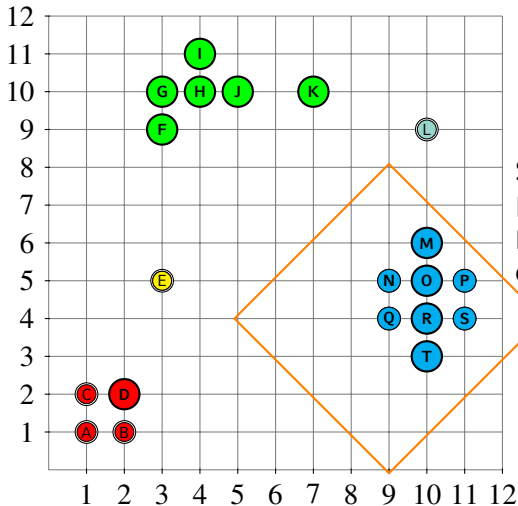
$\varepsilon = 4.1$

$\text{minPts} = 5$

Seed list:

NPQS

E und L nicht
eindeutig!



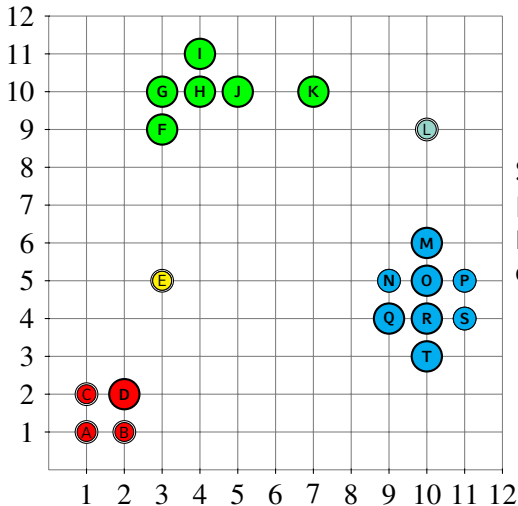
$\varepsilon = 4.1$

$\text{minPts} = 5$

Seed list:

NPS

E und L nicht
eindeutig!



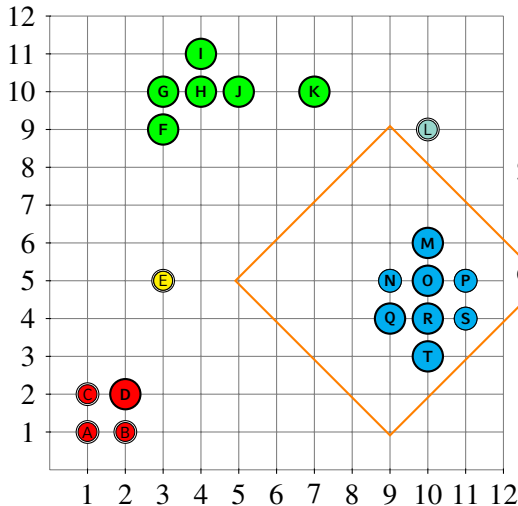
$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

NPS

E und L nicht
eindeutig!



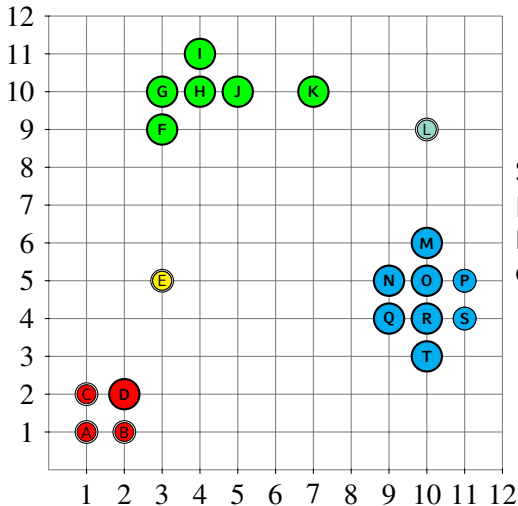
$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

PS

E und L nicht
eindeutig!



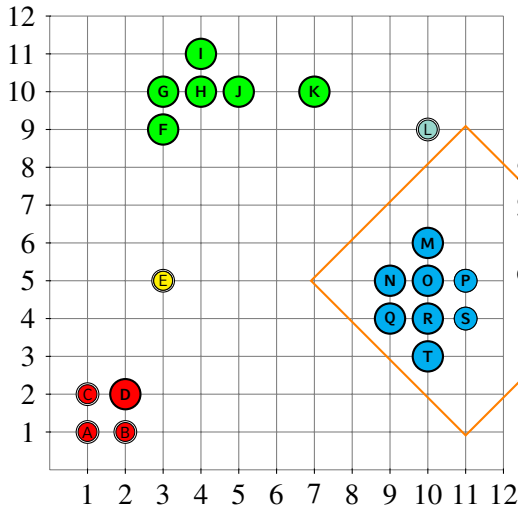
$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

Seed list:

PS

E und L nicht
eindeutig!

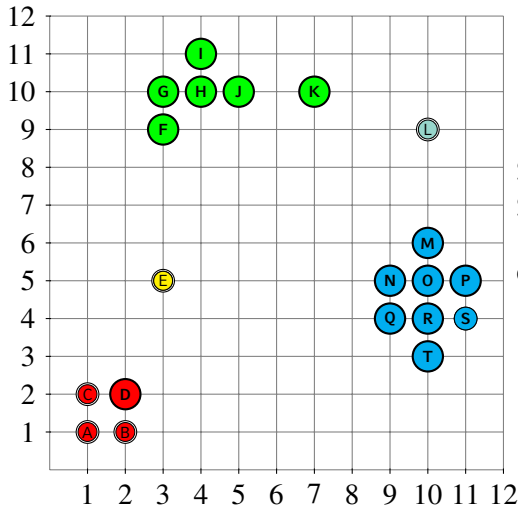


$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

S
E und L nicht
eindeutig!



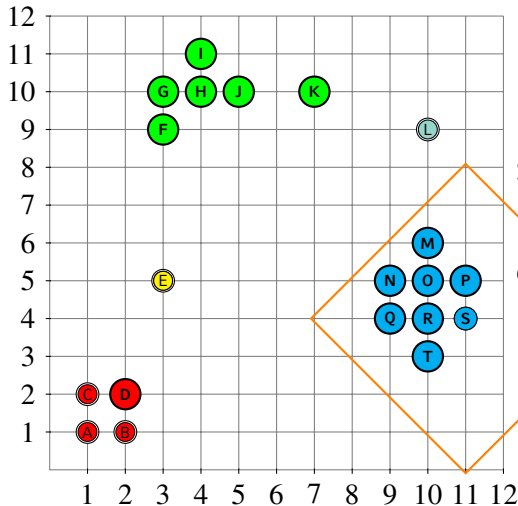
$\varepsilon = 4.1$

$\text{minPts} = 5$

Seed list:

S

E und L nicht
eindeutig!

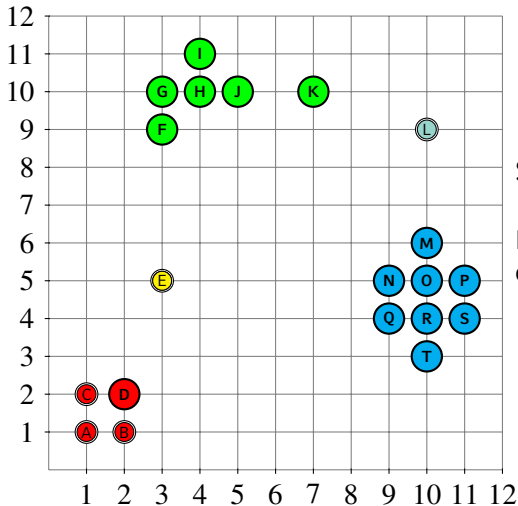


$\epsilon = 4.1$

$\text{minPts} = 5$

Seed list:

E und L nicht
eindeutig!

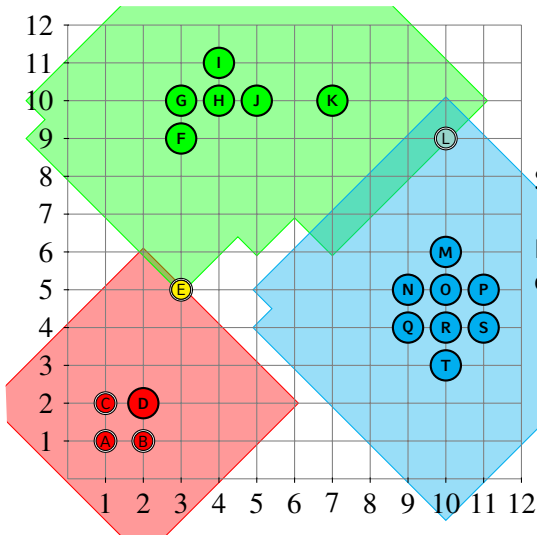


$$\varepsilon = 4.1$$

$$\text{minPts} = 5$$

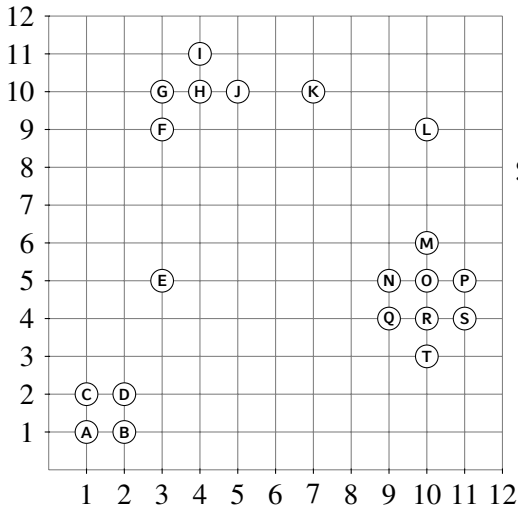
Seed list:

E und L nicht
eindeutig!

$\varepsilon = 1.1$
 $\text{minPts} = 2$ $\varepsilon = 1.1$
 $\text{minPts} = 3$ $\varepsilon = 1.1$
 $\text{minPts} = 4$ $\varepsilon = 2.1$
 $\text{minPts} = 4$ $\varepsilon = 4.1$
 $\text{minPts} = 5$ $\varepsilon = 4.1$
 $\text{minPts} = 4$  $\varepsilon = 4.1$ $\text{minPts} = 5$

Seed list:

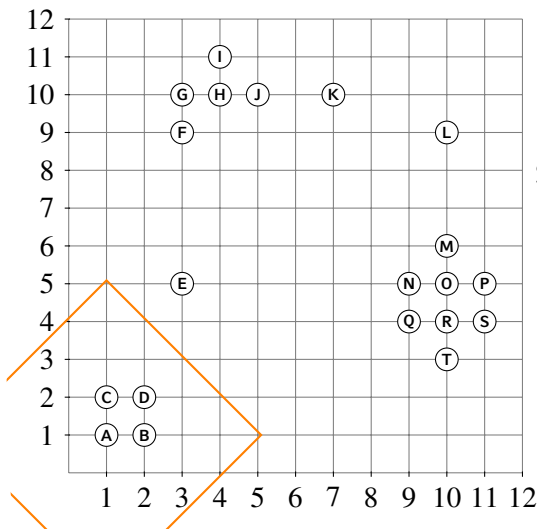
E und L nicht
eindeutig!



$$\epsilon = 4.1$$

$$\text{minPts} = 4$$

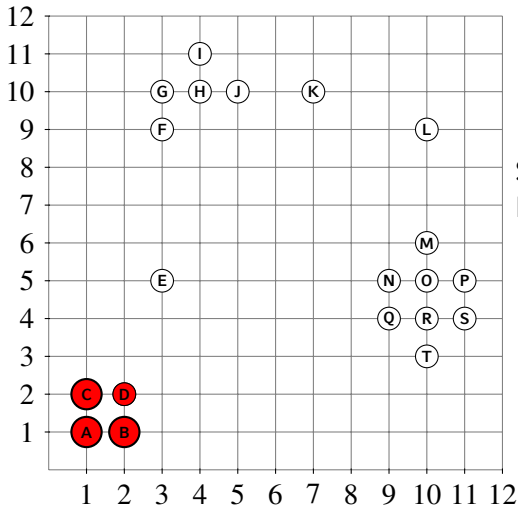
Seeds:



$$\varepsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:

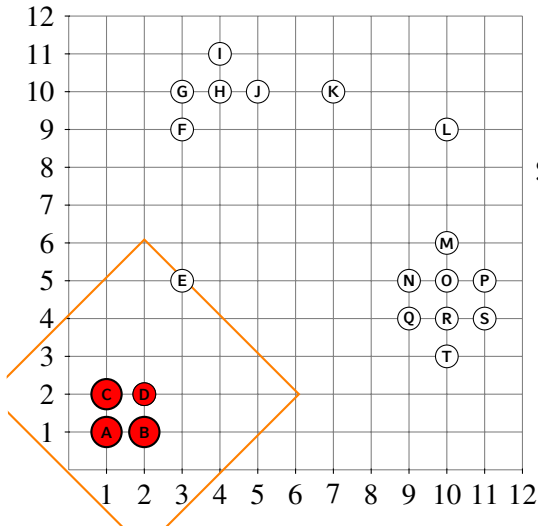


$$\epsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:

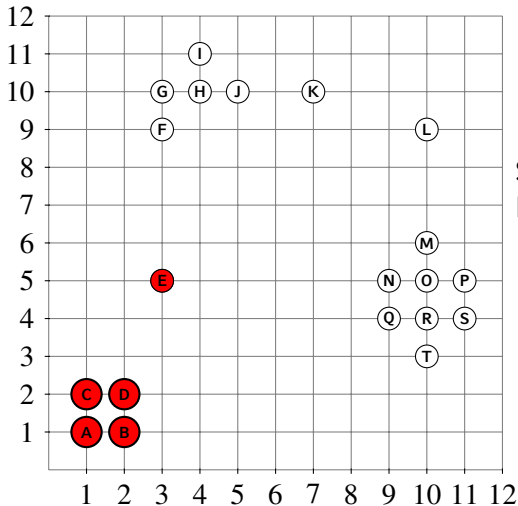
D



$$\varepsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:

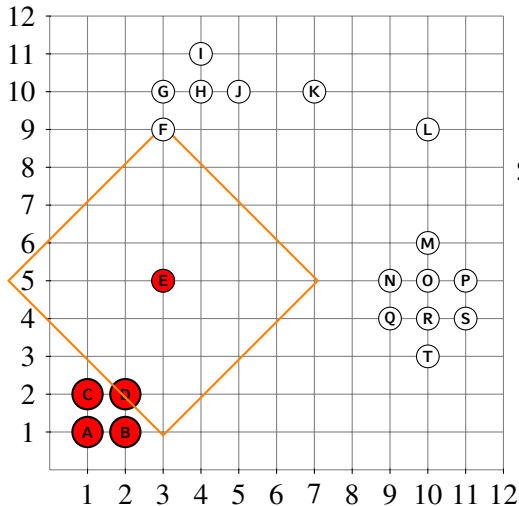


$$\varepsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:

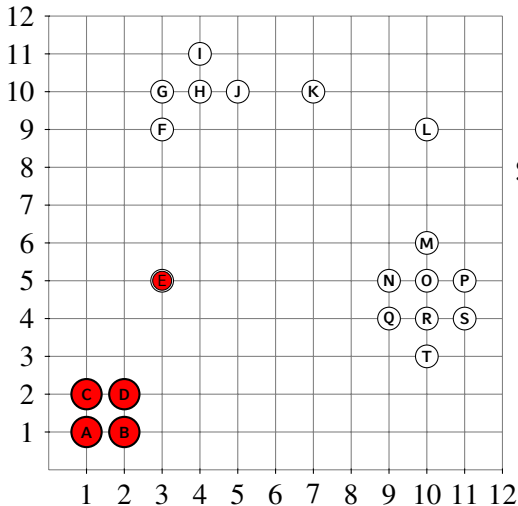
E



$\varepsilon = 4.1$

$\text{minPts} = 4$

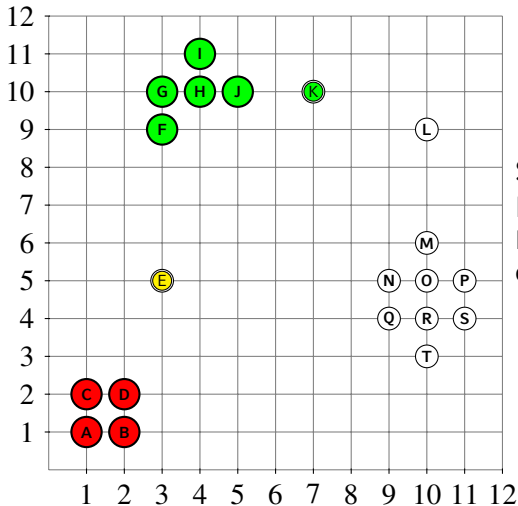
Seeds:



$$\varepsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:



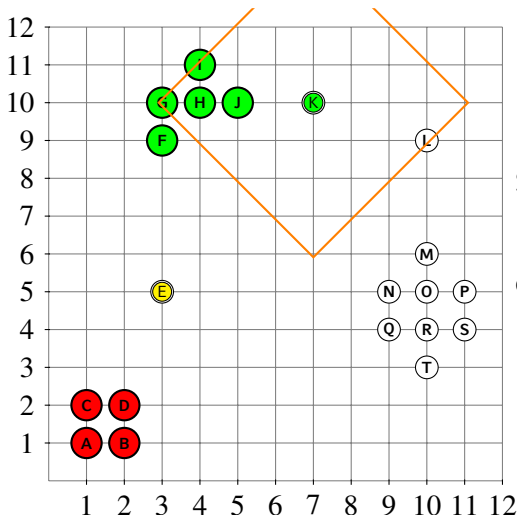
$\varepsilon = 4.1$

$\text{minPts} = 4$

Seeds:

K

E nicht
eindeutig!

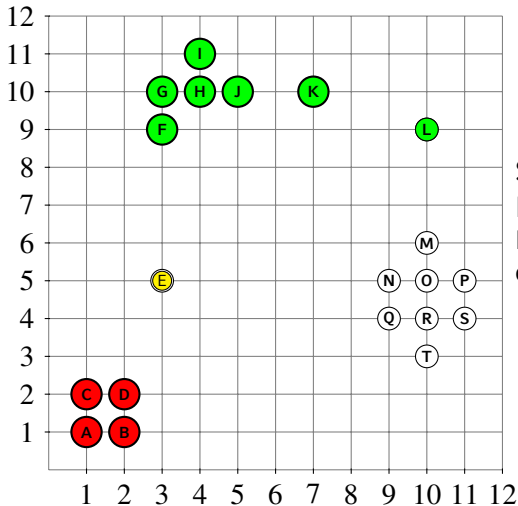


$\varepsilon = 4.1$

$\text{minPts} = 4$

Seeds:

E nicht
eindeutig!



$\epsilon = 4.1$

$\text{minPts} = 4$

Seeds:

L

E nicht
eindeutig!

$\varepsilon = 1.1$
 $\text{minPts} = 2$

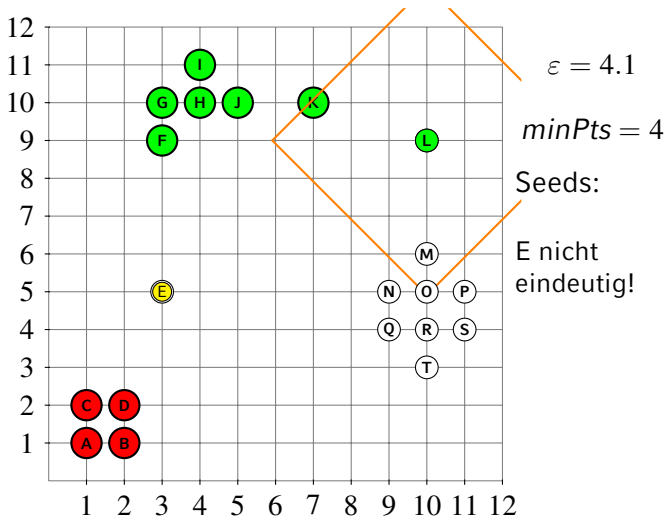
$\varepsilon = 1.1$
 $\text{minPts} = 3$

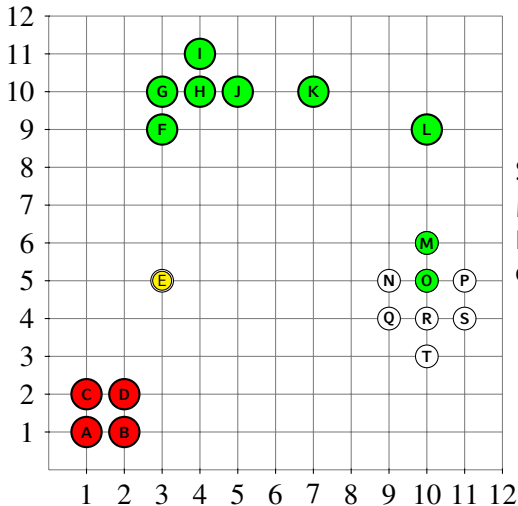
$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

$\varepsilon = 4.1$
 $\text{minPts} = 4$





$$\epsilon = 4.1$$

$$\text{minPts} = 4$$

Seeds:

MO

E nicht
eindeutig!

$\varepsilon = 1.1$
 $\text{minPts} = 2$

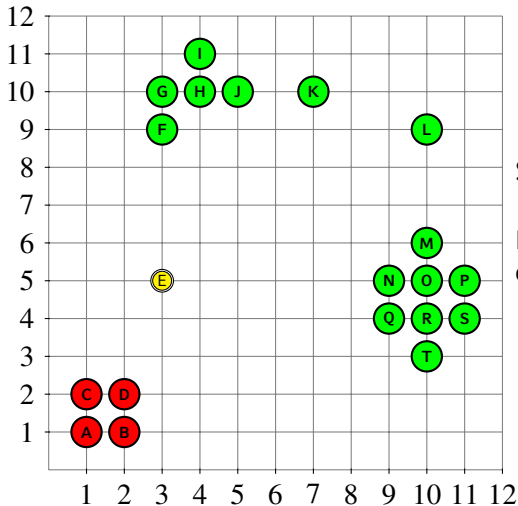
$\varepsilon = 1.1$
 $\text{minPts} = 3$

$\varepsilon = 1.1$
 $\text{minPts} = 4$

$\varepsilon = 2.1$
 $\text{minPts} = 4$

$\varepsilon = 4.1$
 $\text{minPts} = 5$

$\varepsilon = 4.1$
 $\text{minPts} = 4$

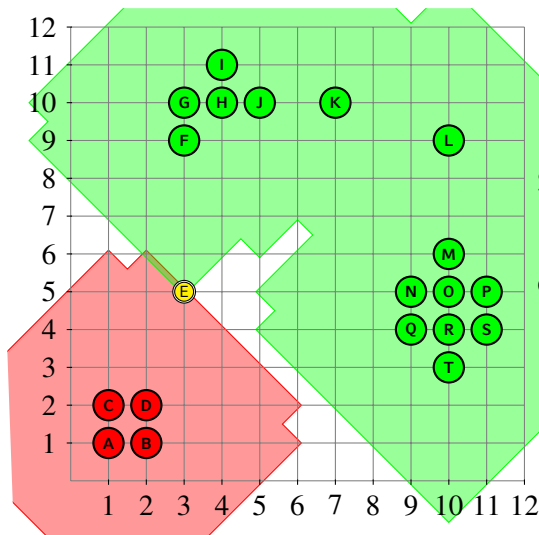


$\varepsilon = 4.1$

$\text{minPts} = 4$

Seeds:

E nicht
eindeutig!

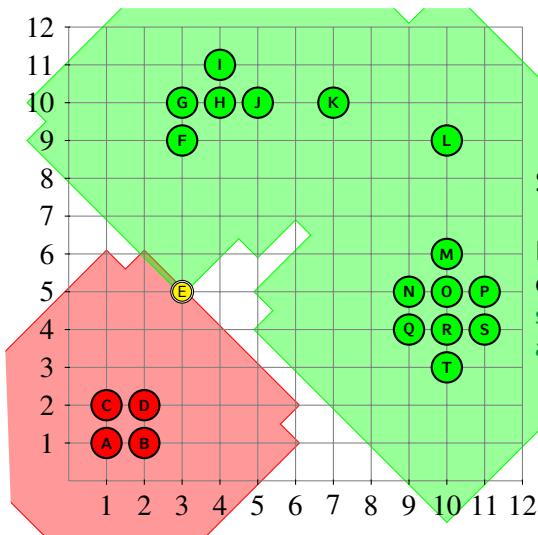


$\epsilon = 4.1$

$\text{minPts} = 4$

Seeds:

E nicht
eindeutig!

$\varepsilon = 1.1$
 $\text{minPts} = 2$ $\varepsilon = 1.1$
 $\text{minPts} = 3$ $\varepsilon = 1.1$
 $\text{minPts} = 4$ $\varepsilon = 2.1$
 $\text{minPts} = 4$ $\varepsilon = 4.1$
 $\text{minPts} = 5$ $\varepsilon = 4.1$
 $\text{minPts} = 4$  $\varepsilon = 4.1$ $\text{minPts} = 4$

Seeds:

E nicht
eindeutig!
single-link
artiger Effekt