Week 7 Video 1

Clustering

Clustering

- A type of ***Structure Discovery*** algorithm

- This type of method is also referred to as ***Dimensionality Reduction***, based on a common application

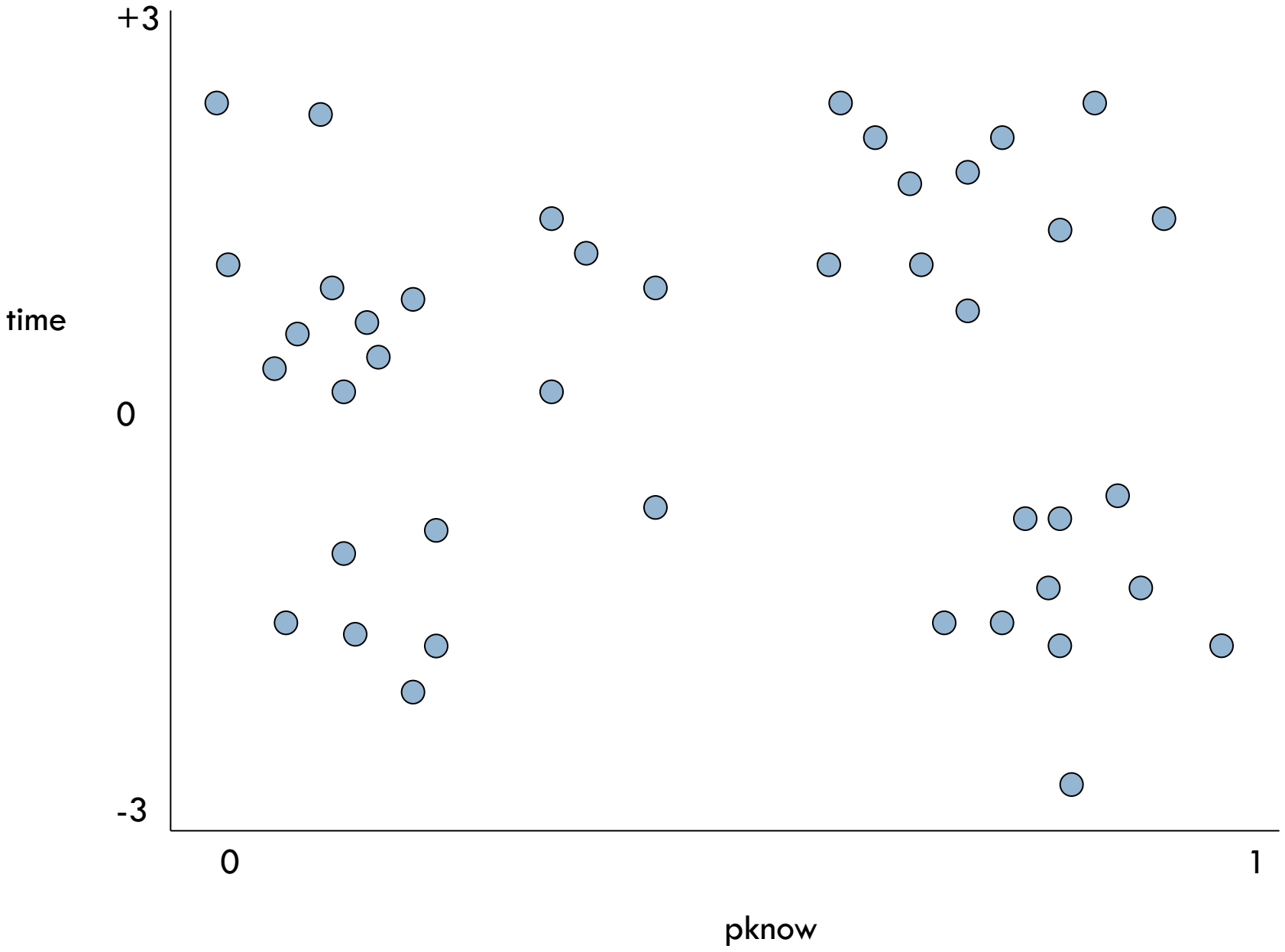
Clustering

- You have a large number of data points
- You want to find what structure there is among the data points
- You don't know anything a priori about the structure
- Clustering tries to find data points that "group together"

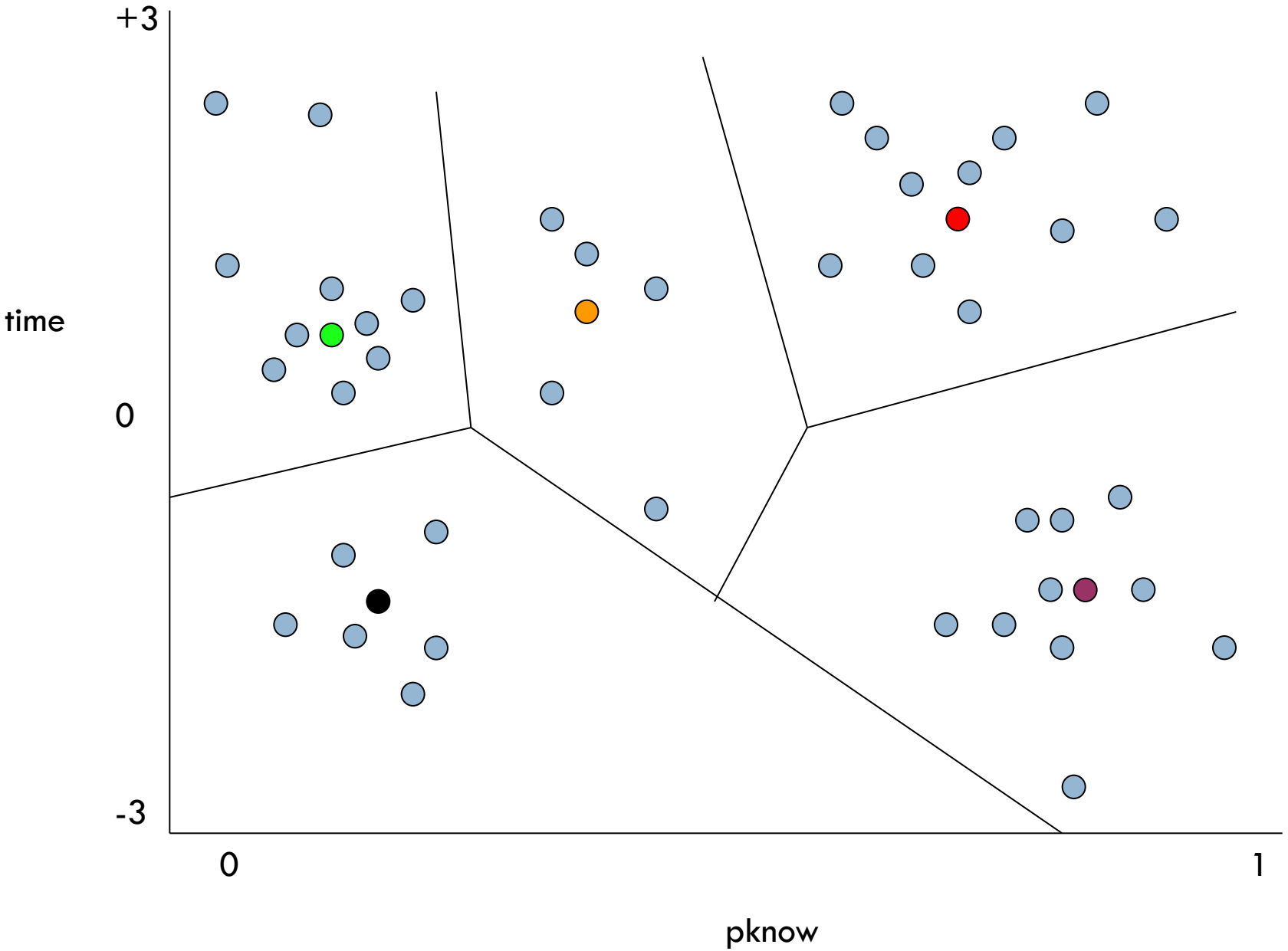
Trivial Example

- Let's say your data has two variables
  - Probability the student knows the skill from BKT (Pknow)
  - Unitized Time

- Note: clustering works for (and is effective in) large feature spaces


+3
time
0
-3
0
1
pknow

k-Means Clustering Algorithm

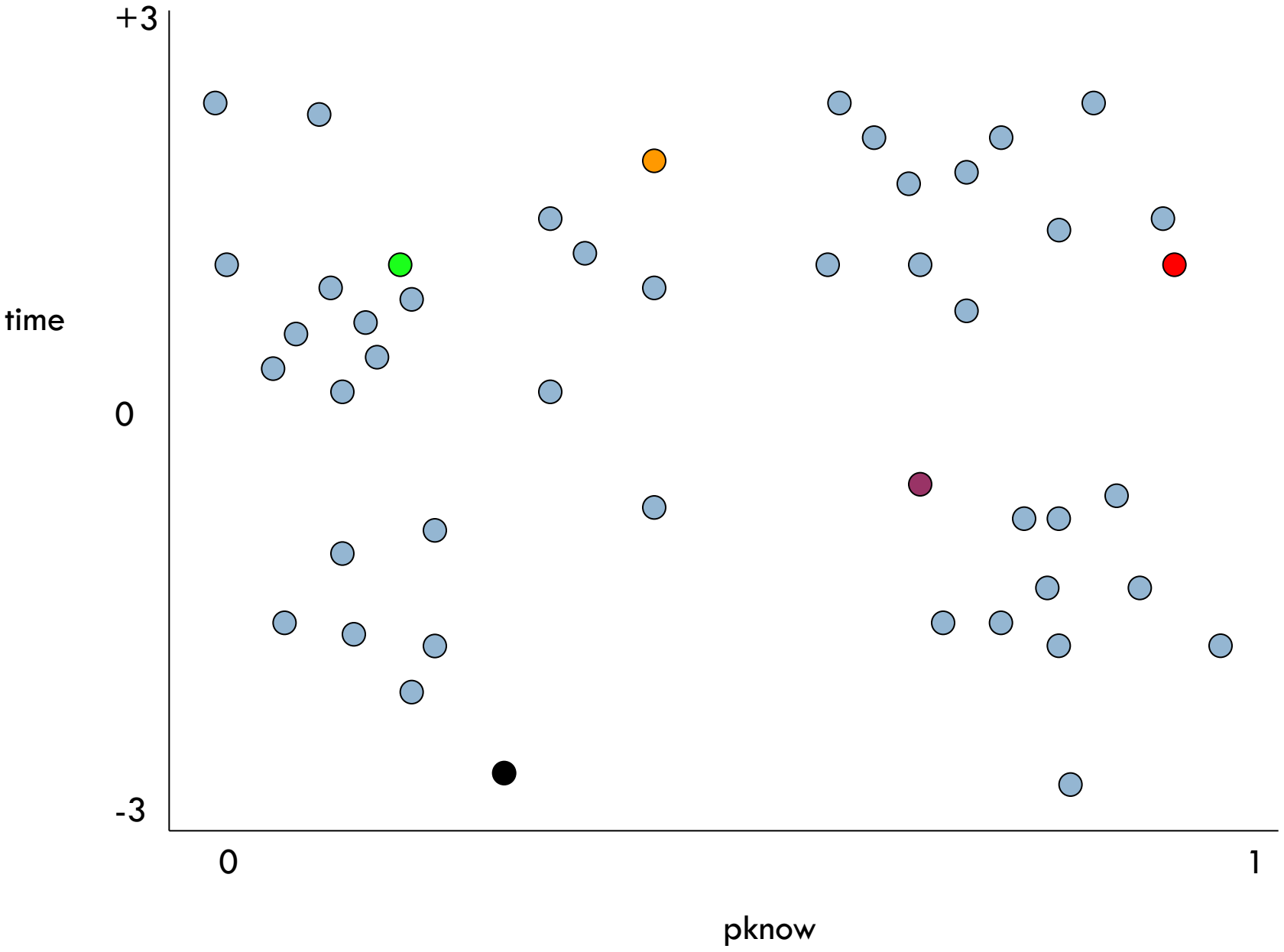


Not the only clustering algorithm

- Just the simplest
- We'll discuss fancier ones as the week goes on

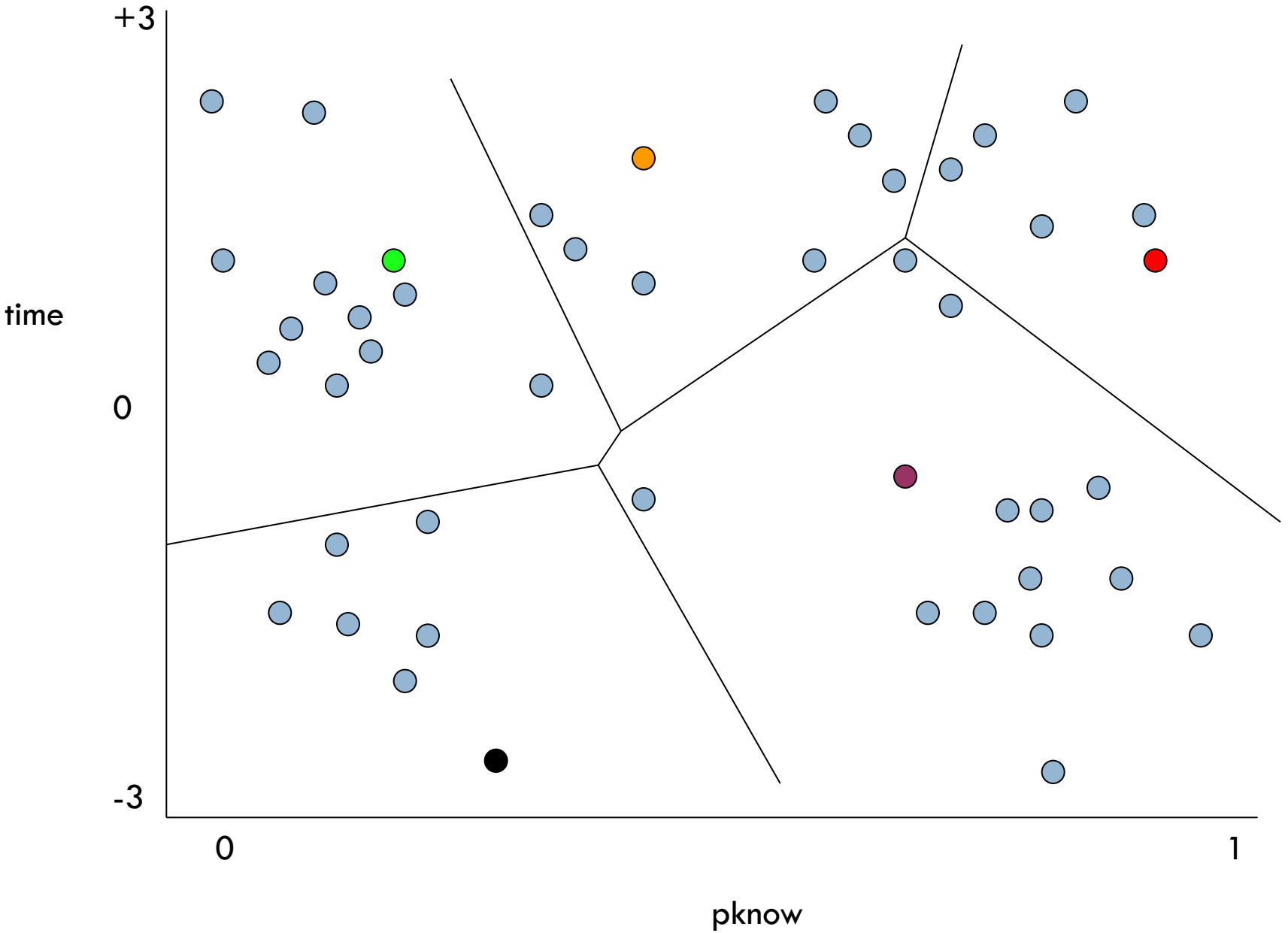
How did we get these clusters?

- First we decided how many clusters we wanted, 5
  - How did we do that? More on this in the next lecture
- We picked starting values for the "centroids" of the clusters…
  - Usually chosen randomly
  - Sometimes there are good reasons to start with specific initial values…


+3
time
0
-3
0
1
pknow

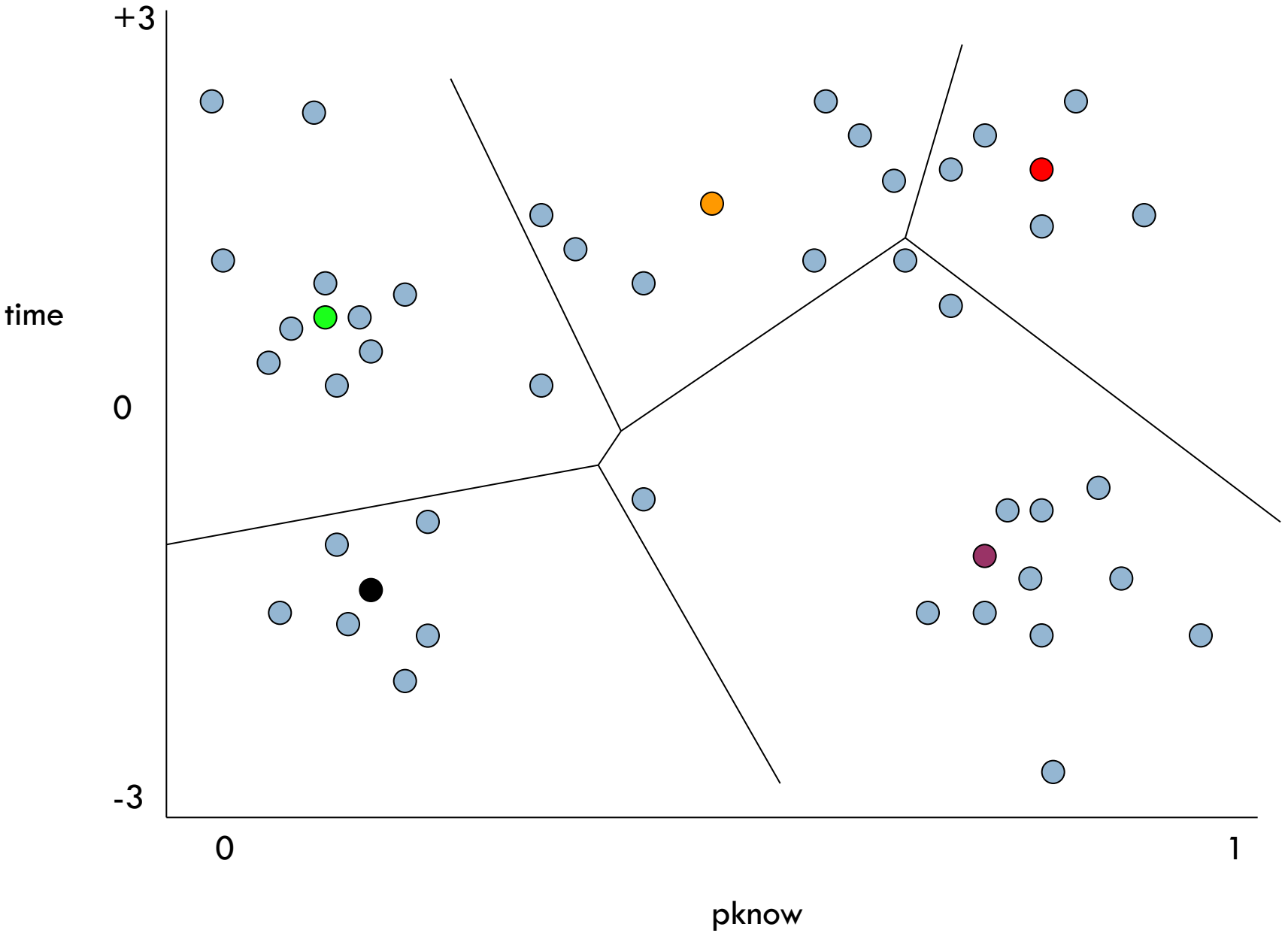
Then…

- We classify every point as to which centroid it's closest to
  - This defines the clusters
  - Typically visualized as a *voronoi diagram*


+3
time
0
-3
0
1
pknow

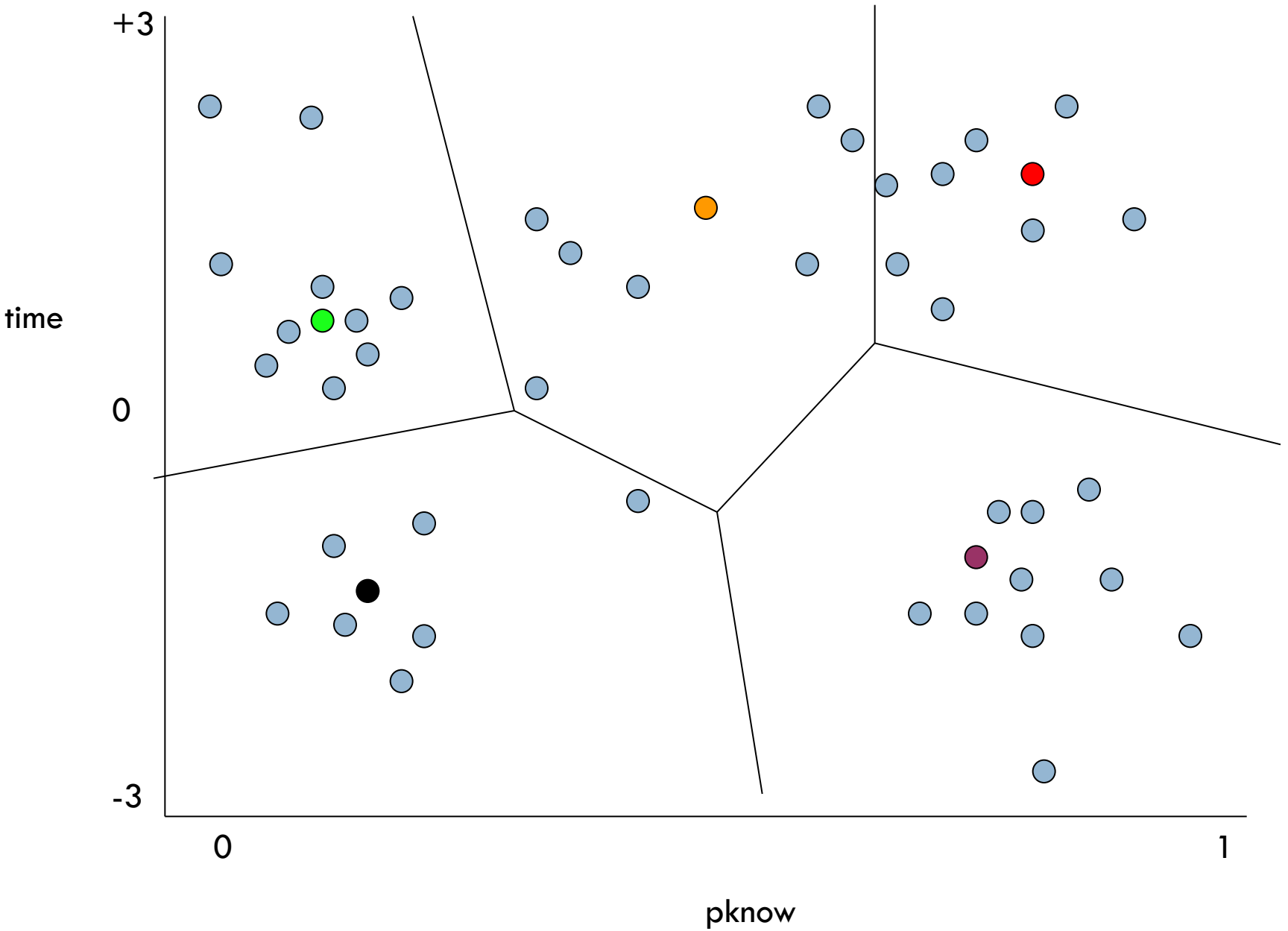
Then…

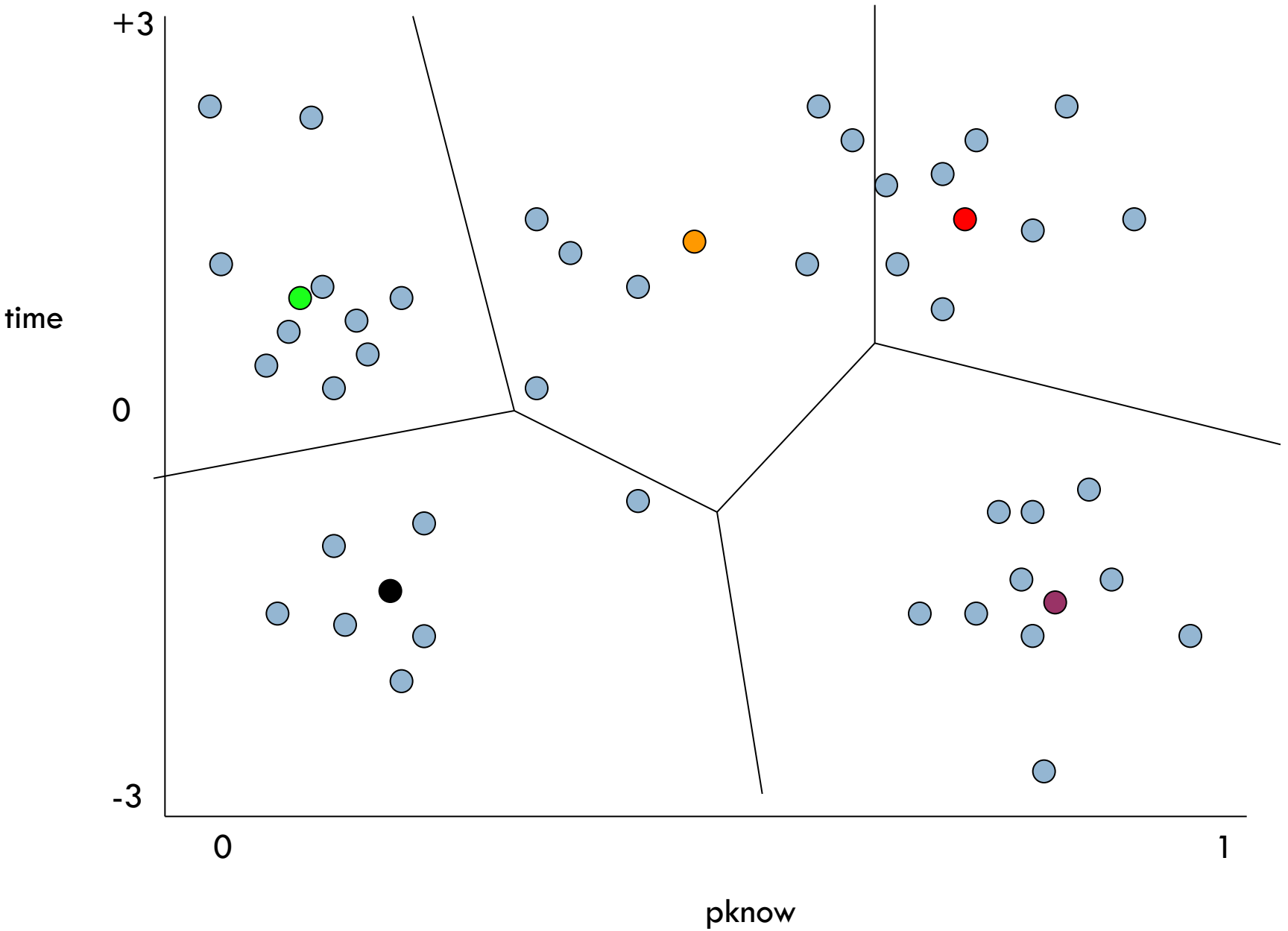
- We re-fit the centroids as the center of the points in each cluster

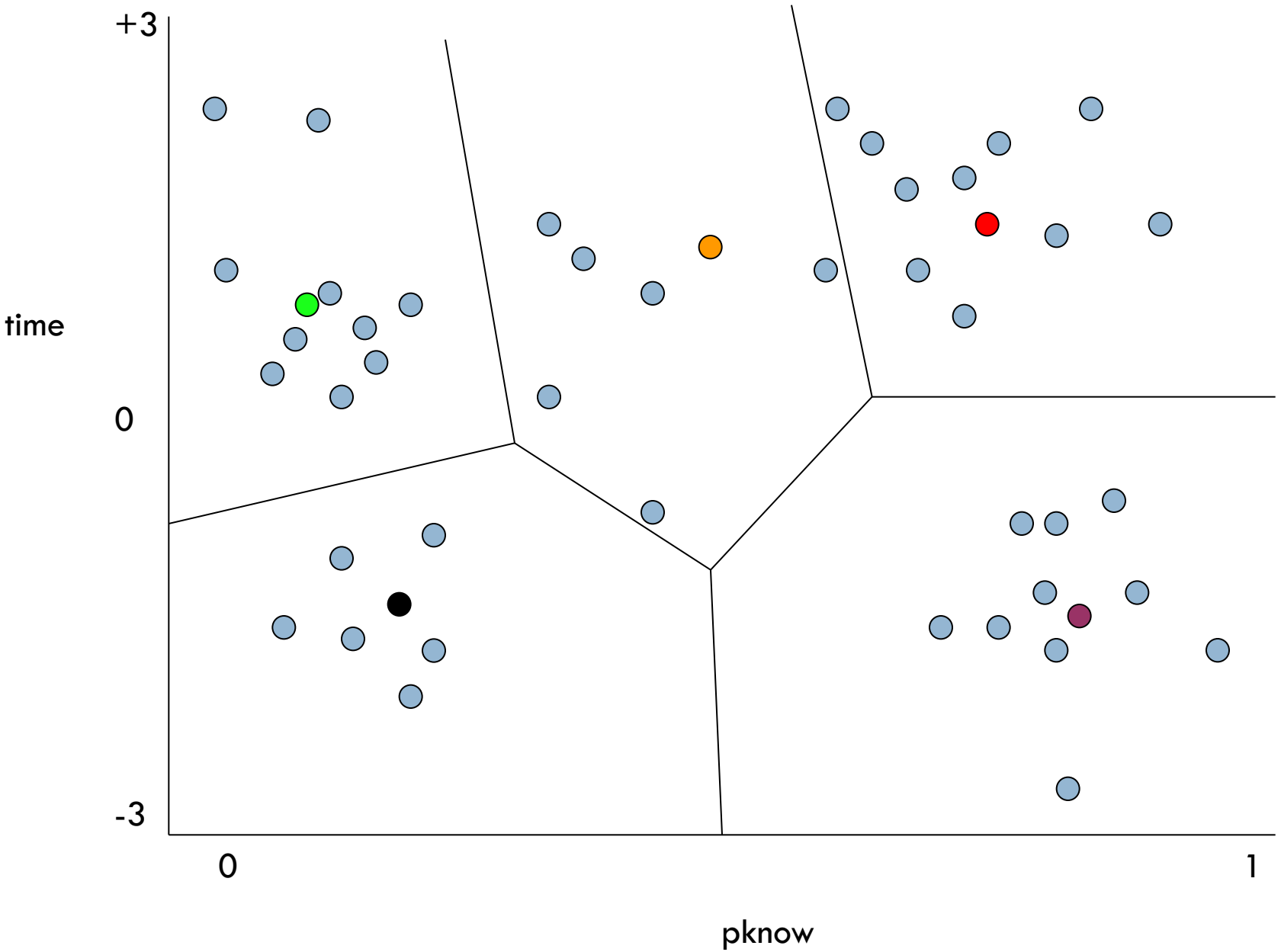

+3
time
0
-3
0
1
pknow

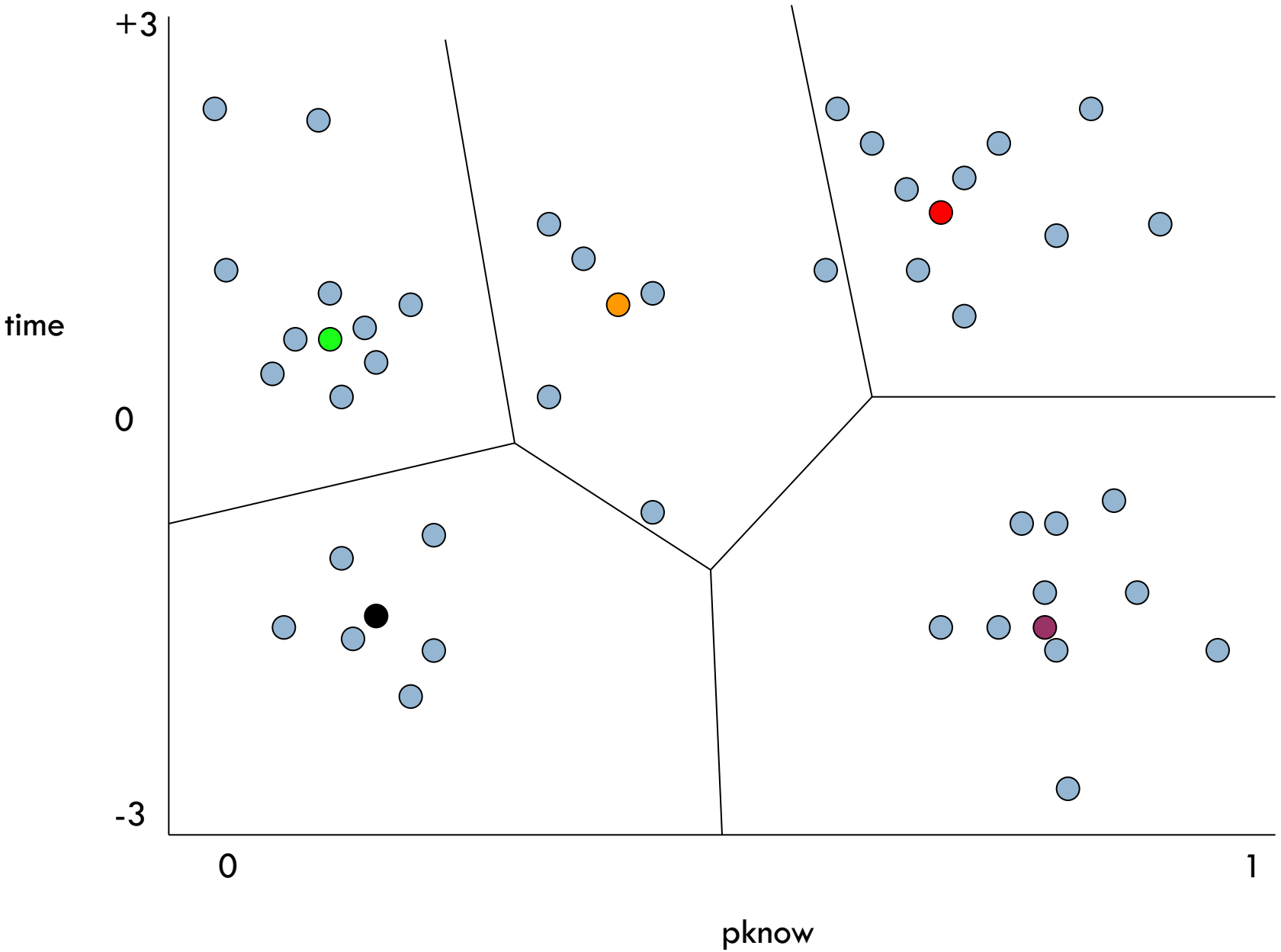
Then…

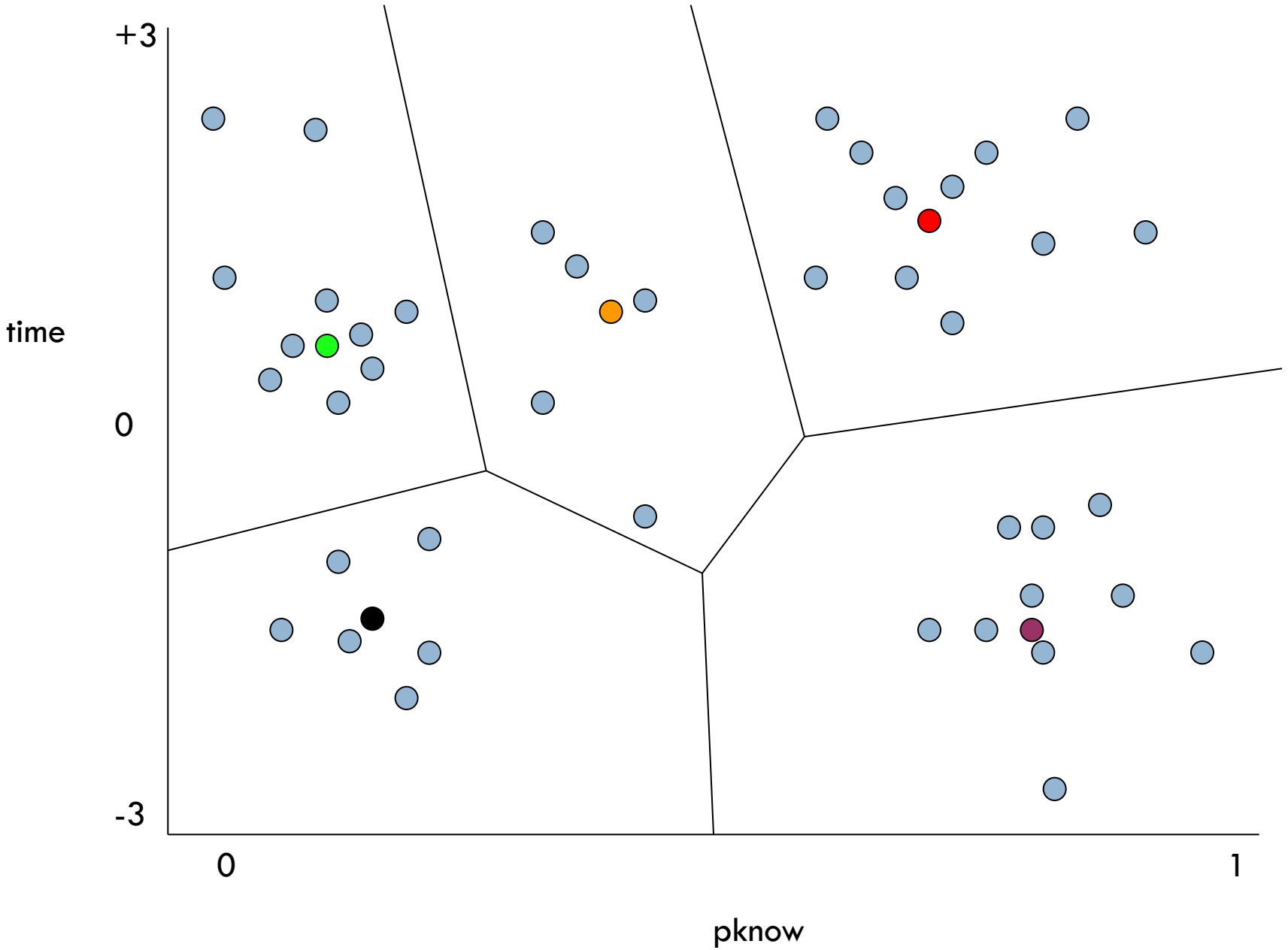
- Repeat the process until the centroids stop moving
- “Convergence”


+3
time
0
-3
0
1
pknow

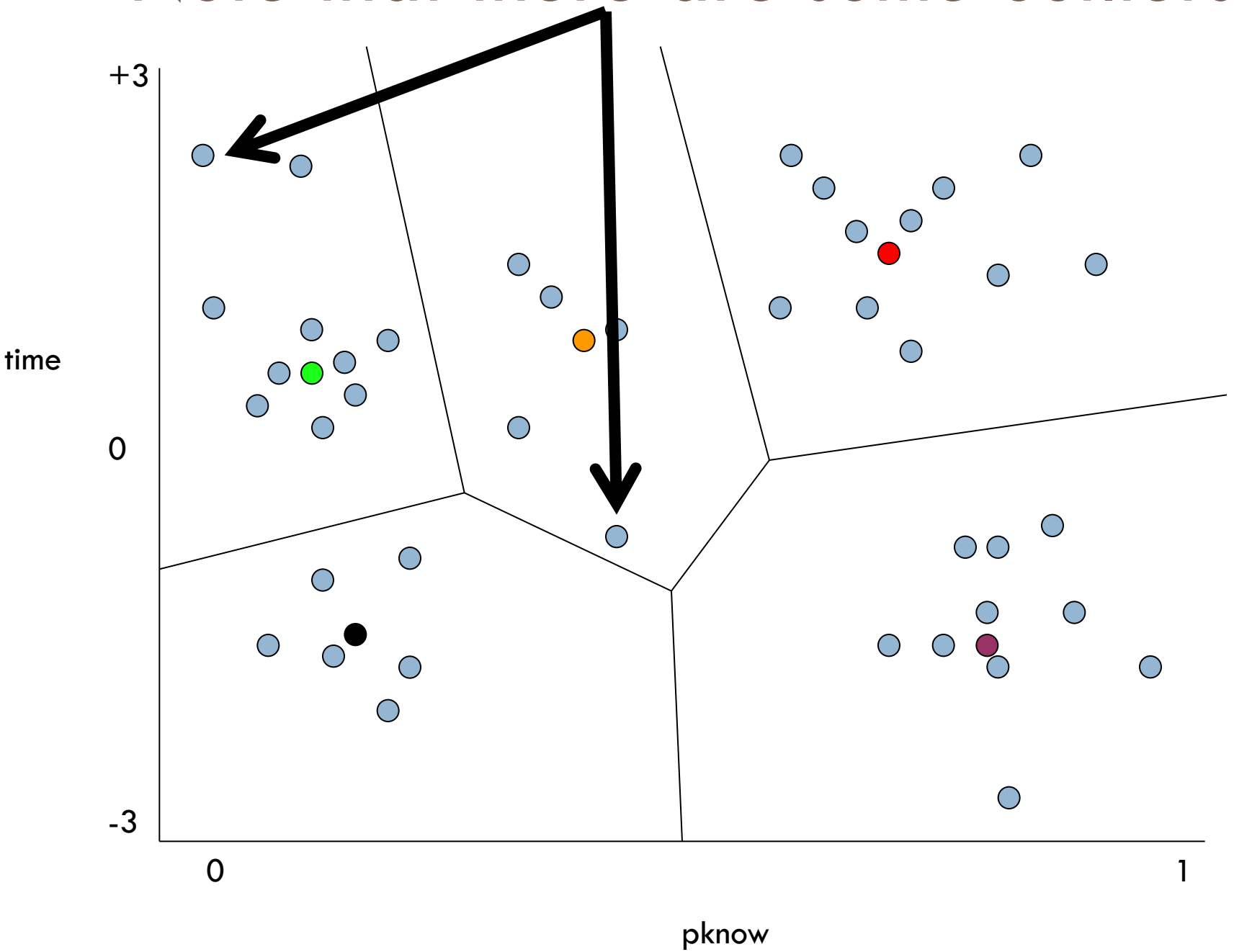

+3
time
0
-3
0
1
pknow


+3
time
0
-3
0
1
pknow

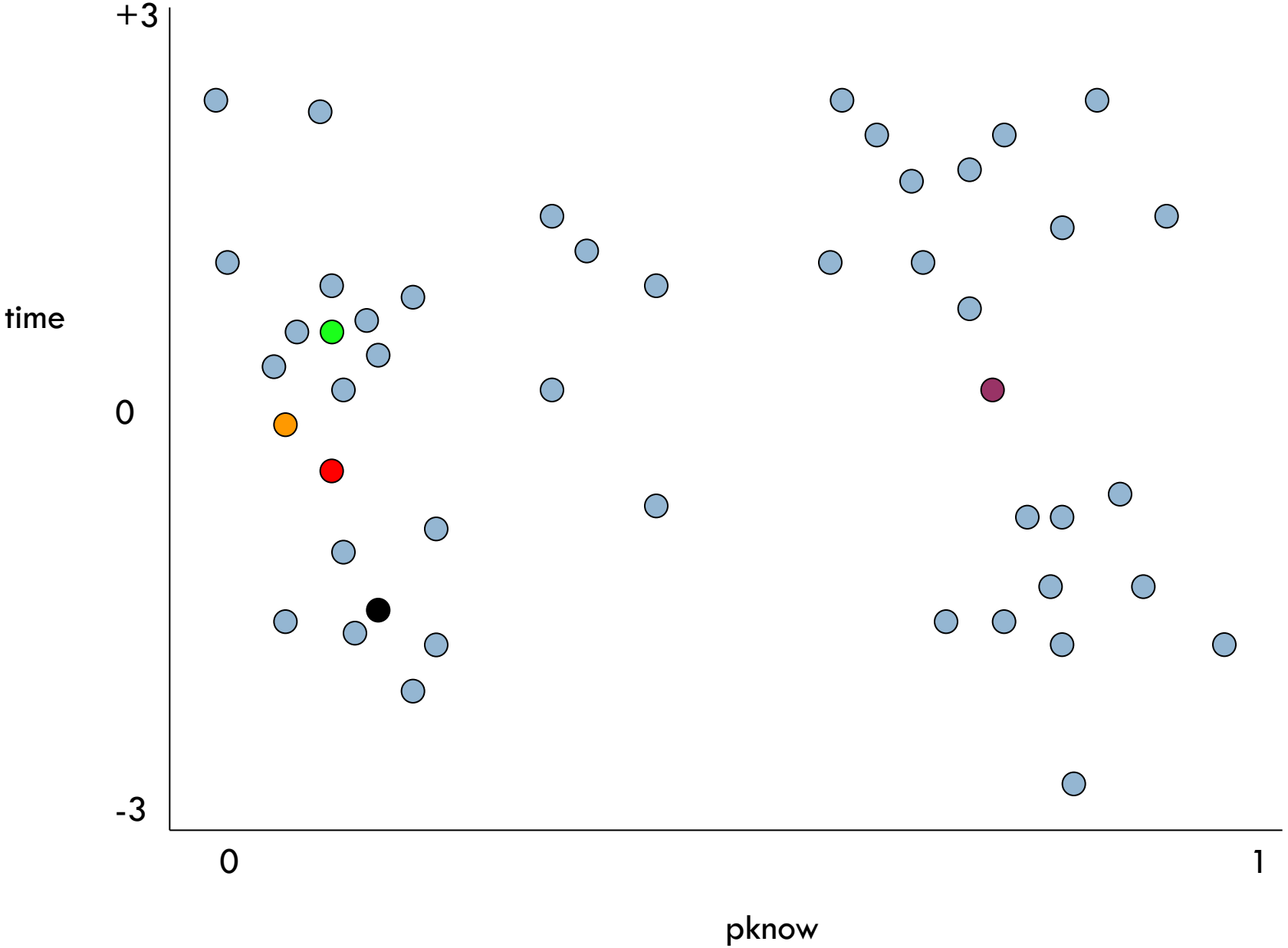

+3
time
0
-3
0
1
pknow


+3
time
0
-3
0
1
pknow

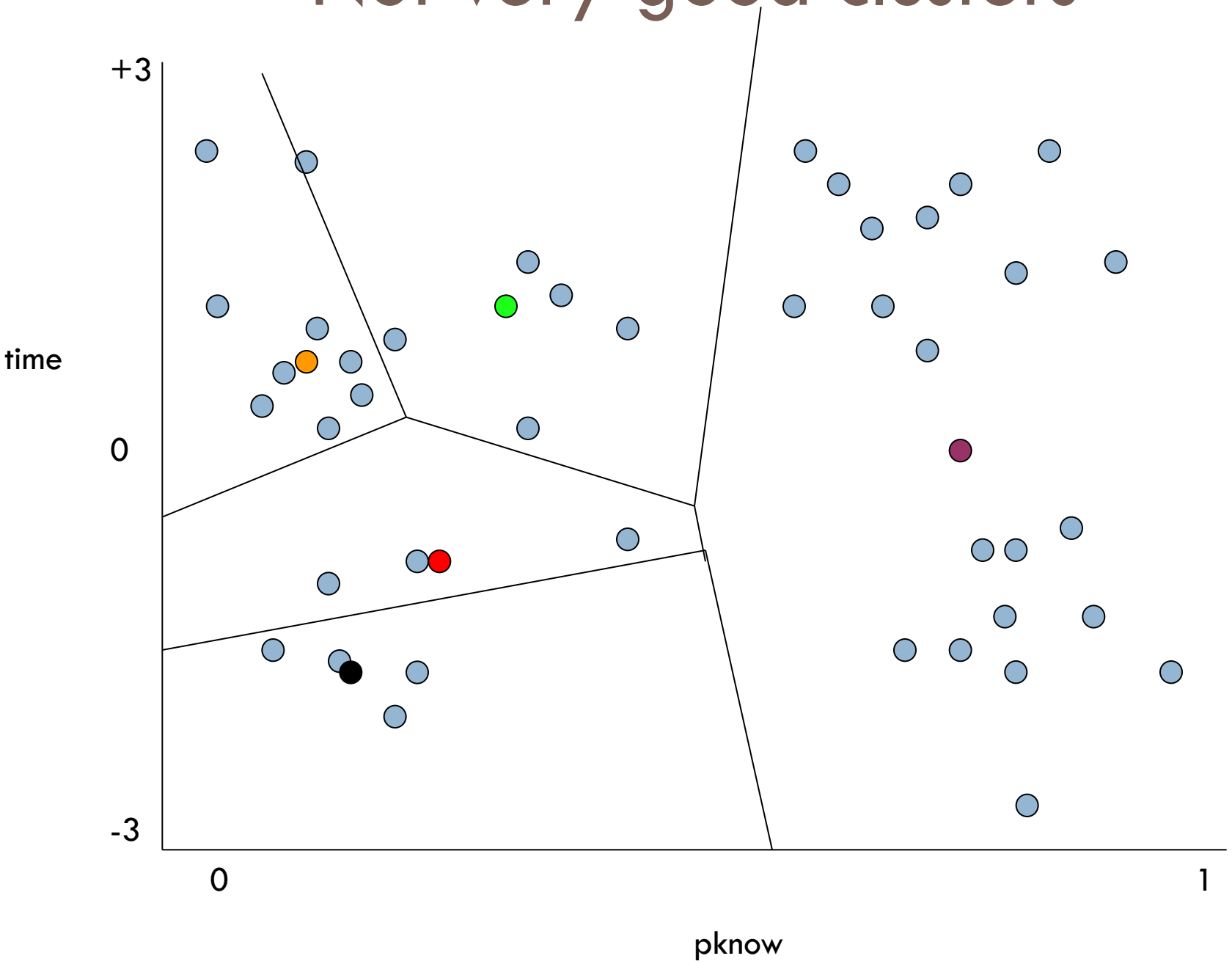
Note that there are some outliers



What if we start with these points?



Not very good clusters



What happens?

- What happens if your starting points are in strange places?
- Not trivial to avoid, considering the full span of possible data distributions

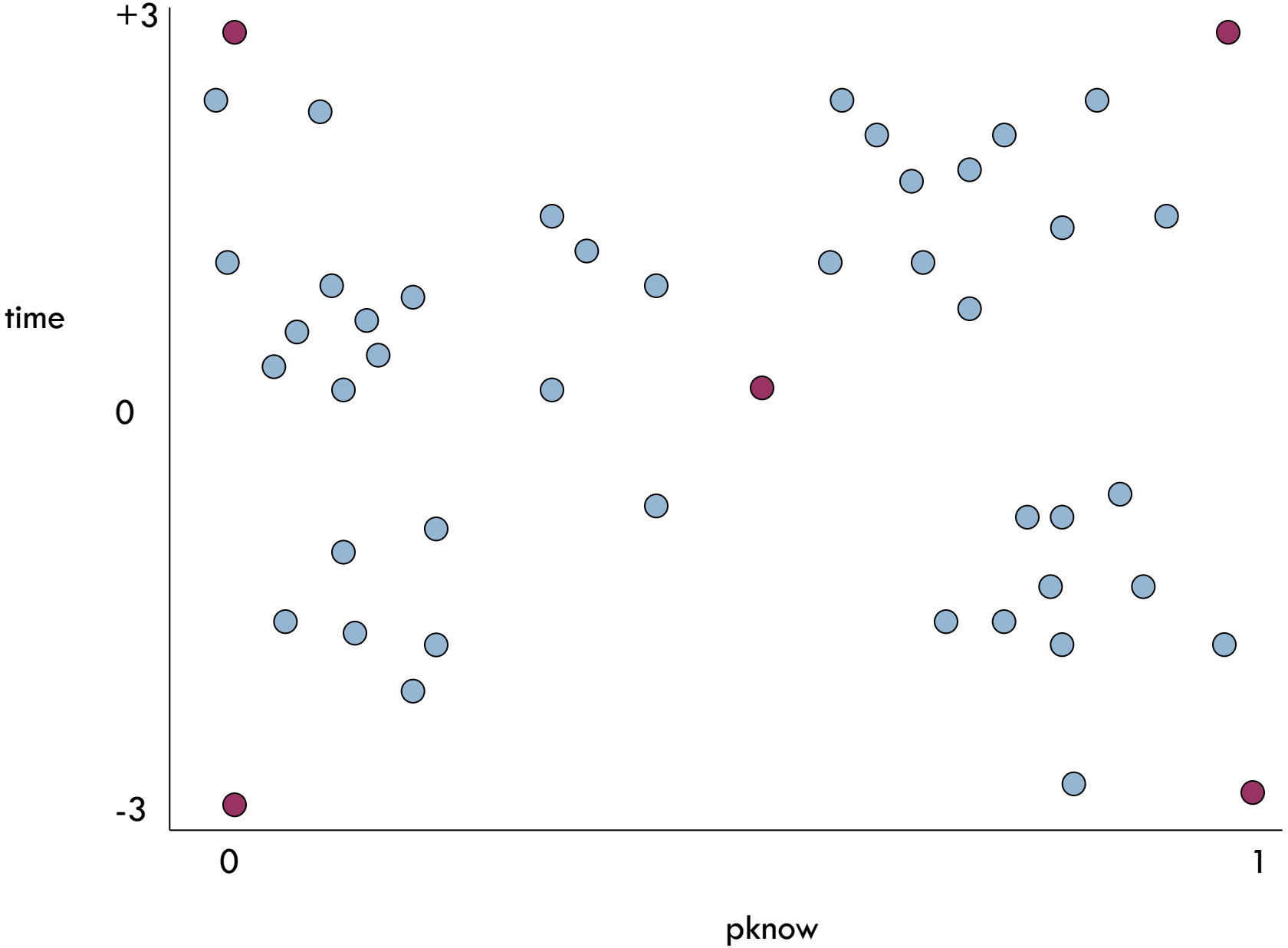
One Solution

- Run several times, involving different starting points
- cf. Conati & Amershi (2009)


Exercises

- Take the following examples
- (The slides will be available in course materials so you can work through them)
- And execute k-means for them
- Do this by hand…
- Focus on getting the concept rather than the exact right answer…
- (Solutions are by hand rather than actually using code, and are not guaranteed to be perfect)

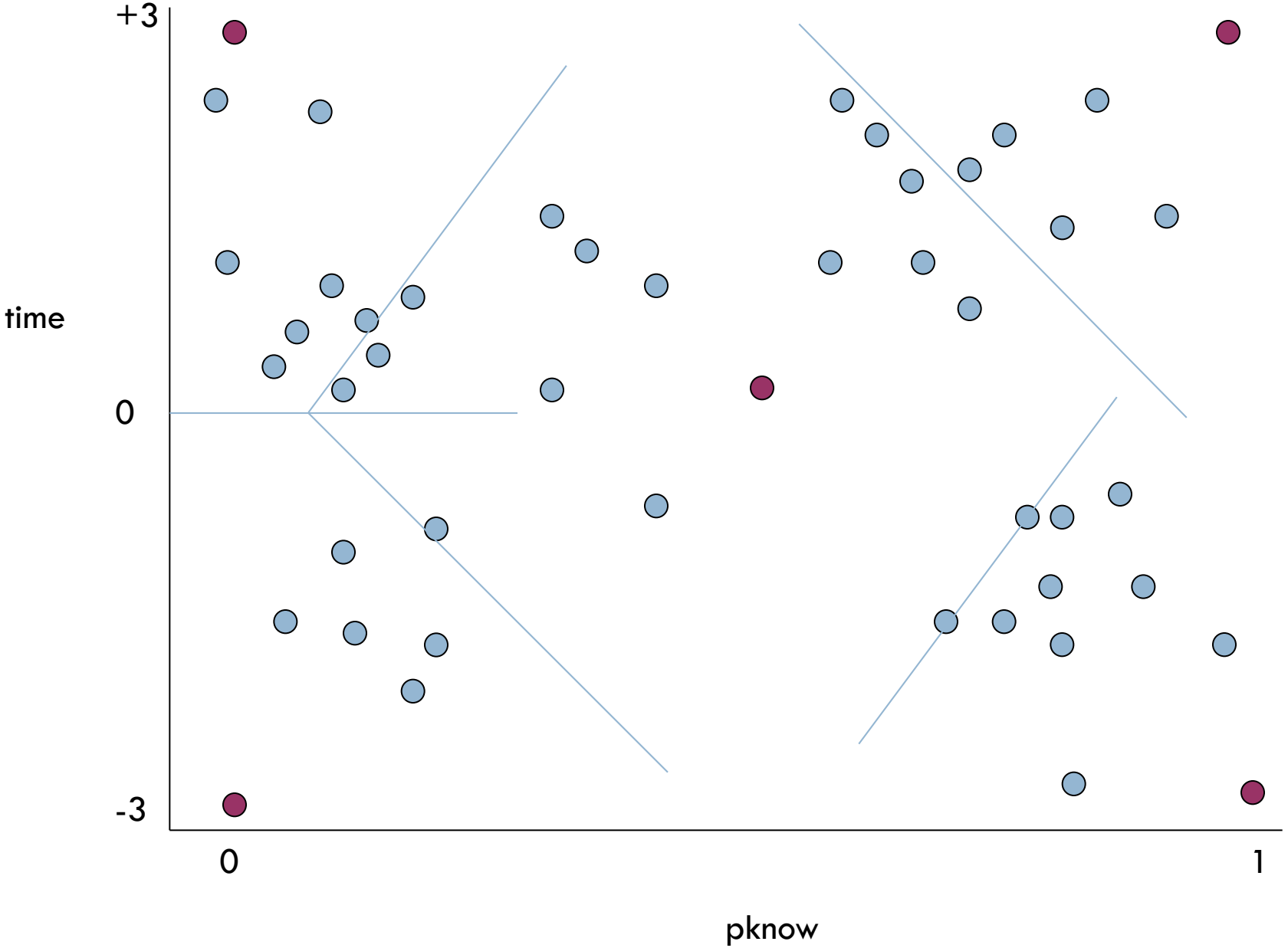
Exercise 7-1-1



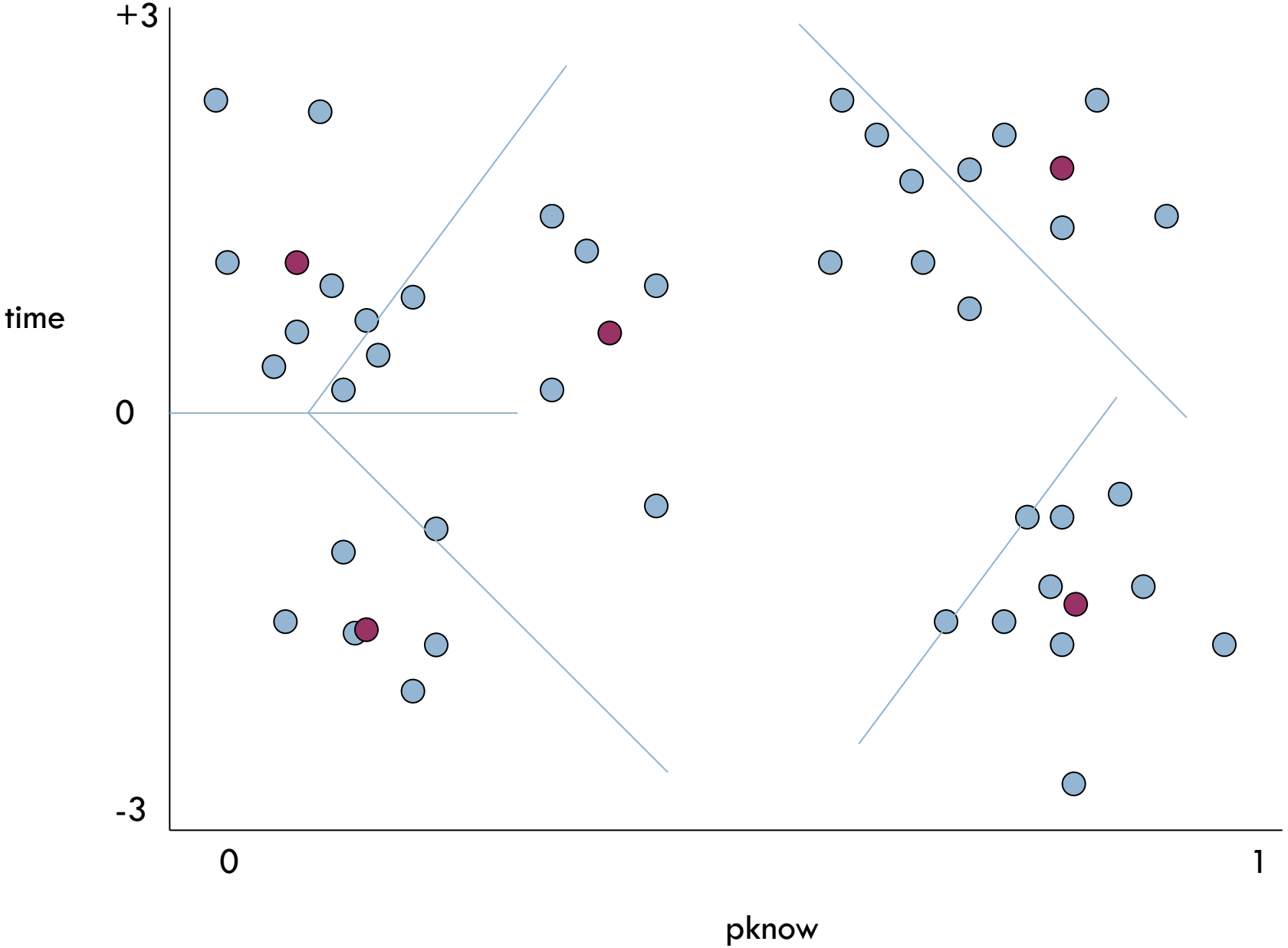
Pause Here with In-Video Quiz

- Do this yourself if you want to
- Only quiz option: go ahead

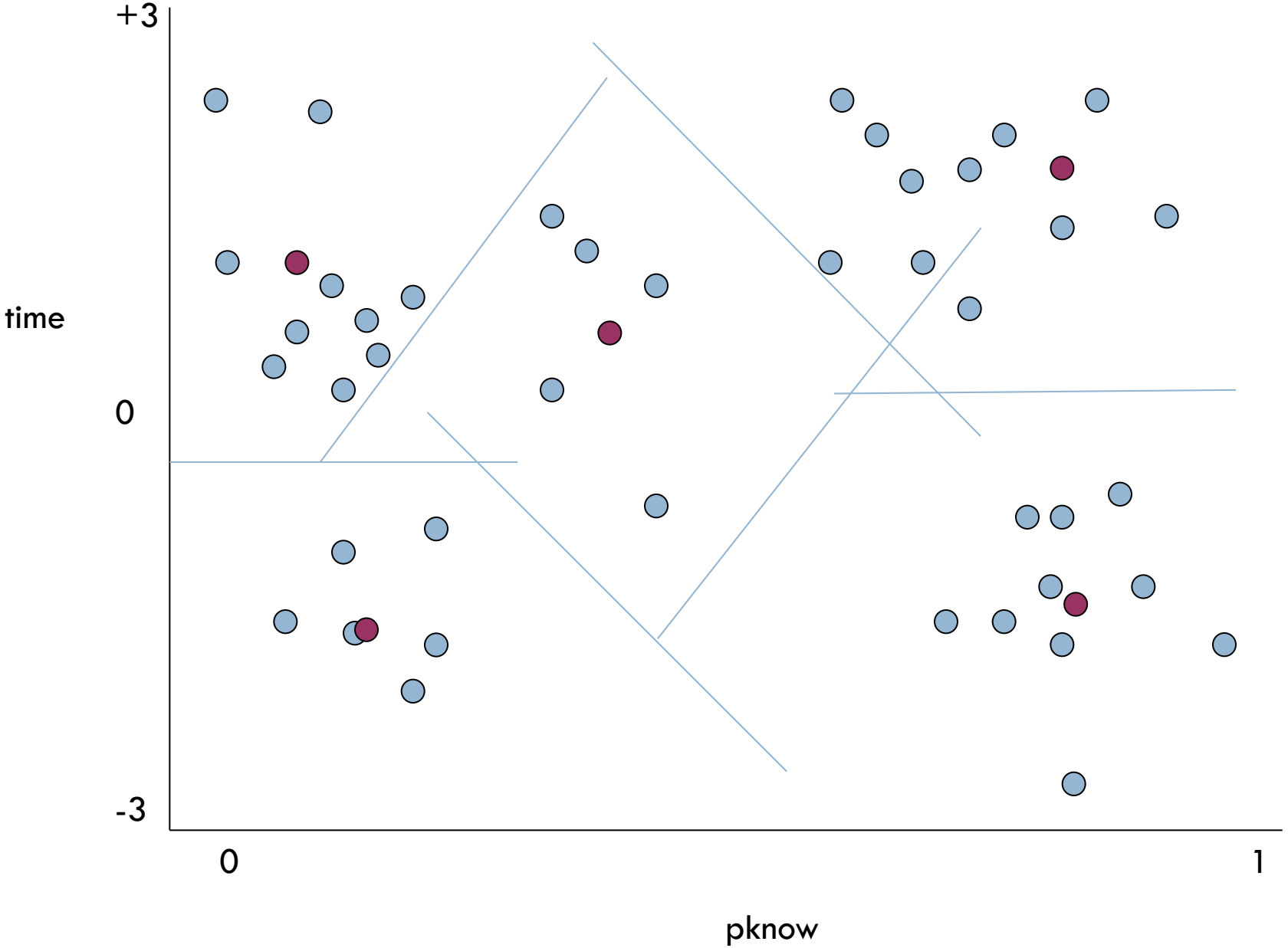
Solution Step 1



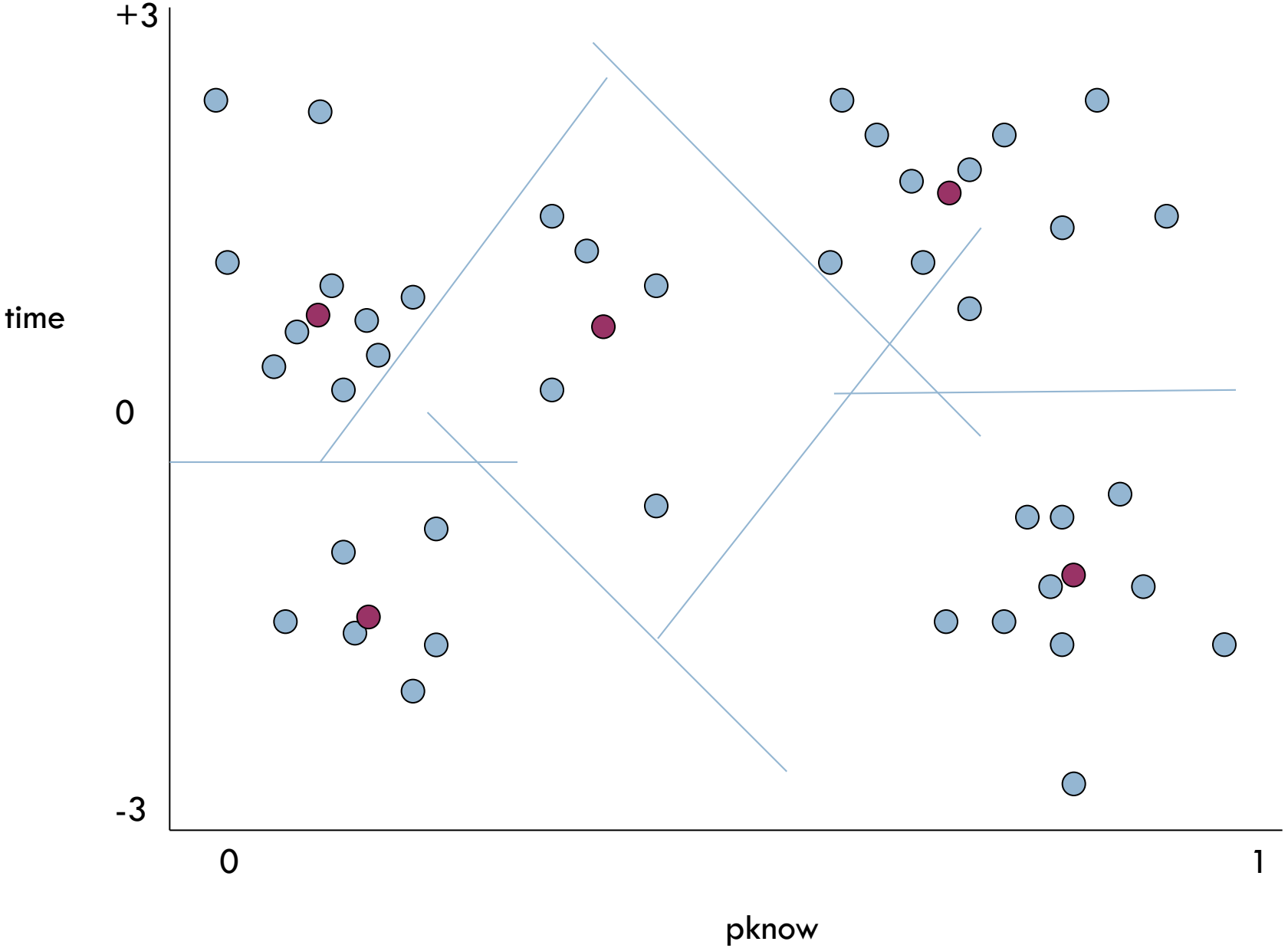
Solution Step 2



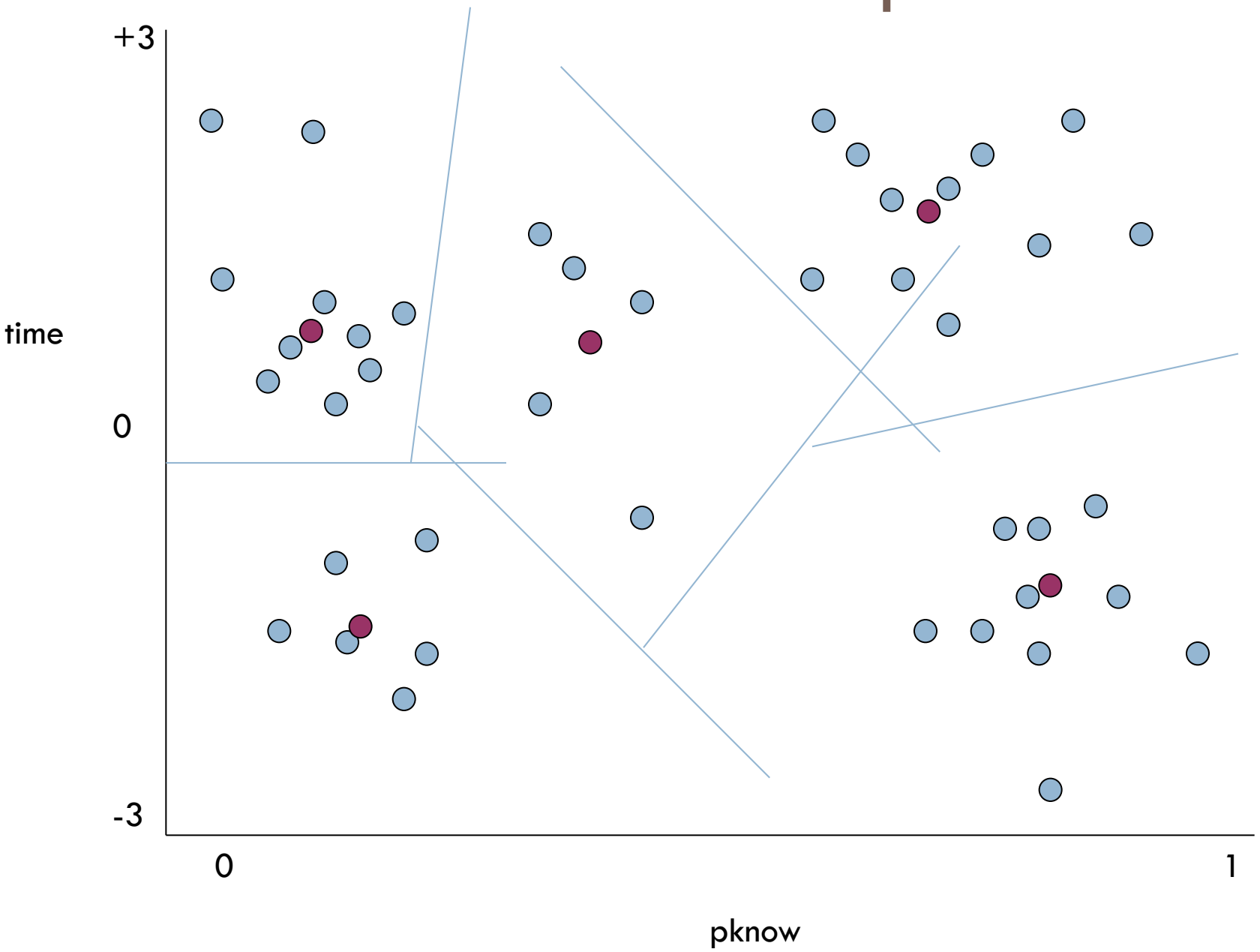
Solution Step 3



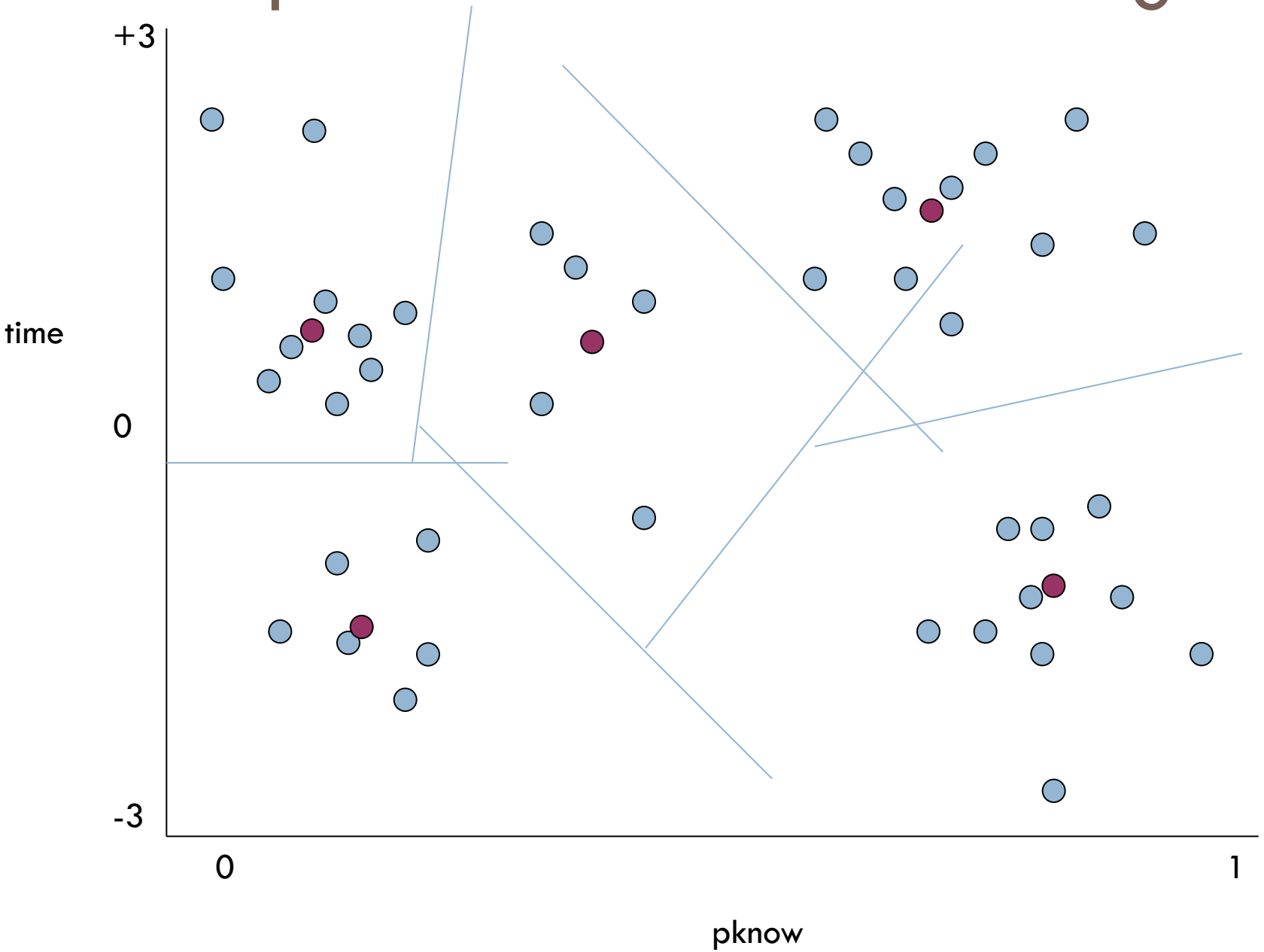
Solution Step 4



Solution Step 5



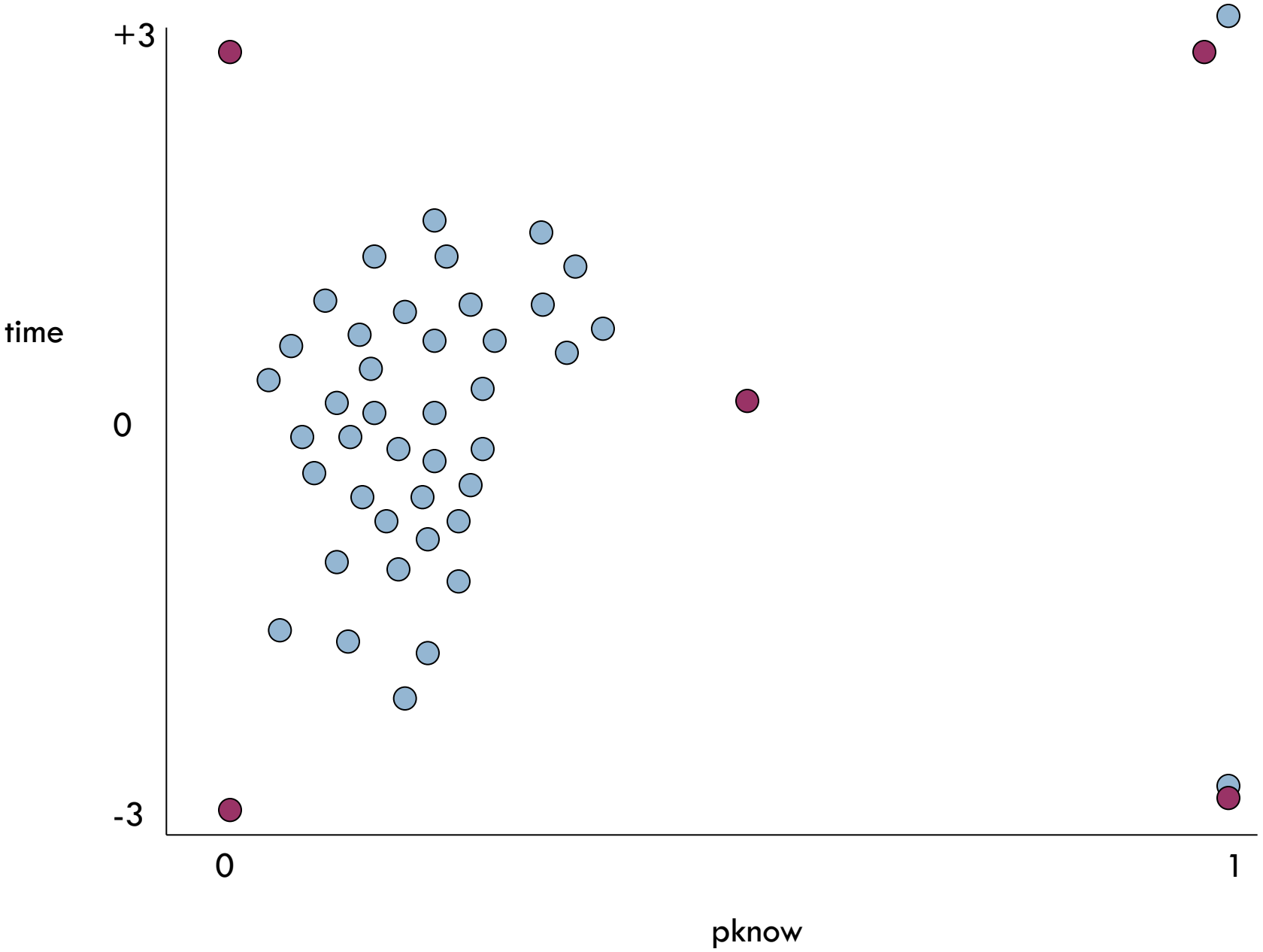
No points switched -- convergence



Notes

- K-Means did pretty reasonable here

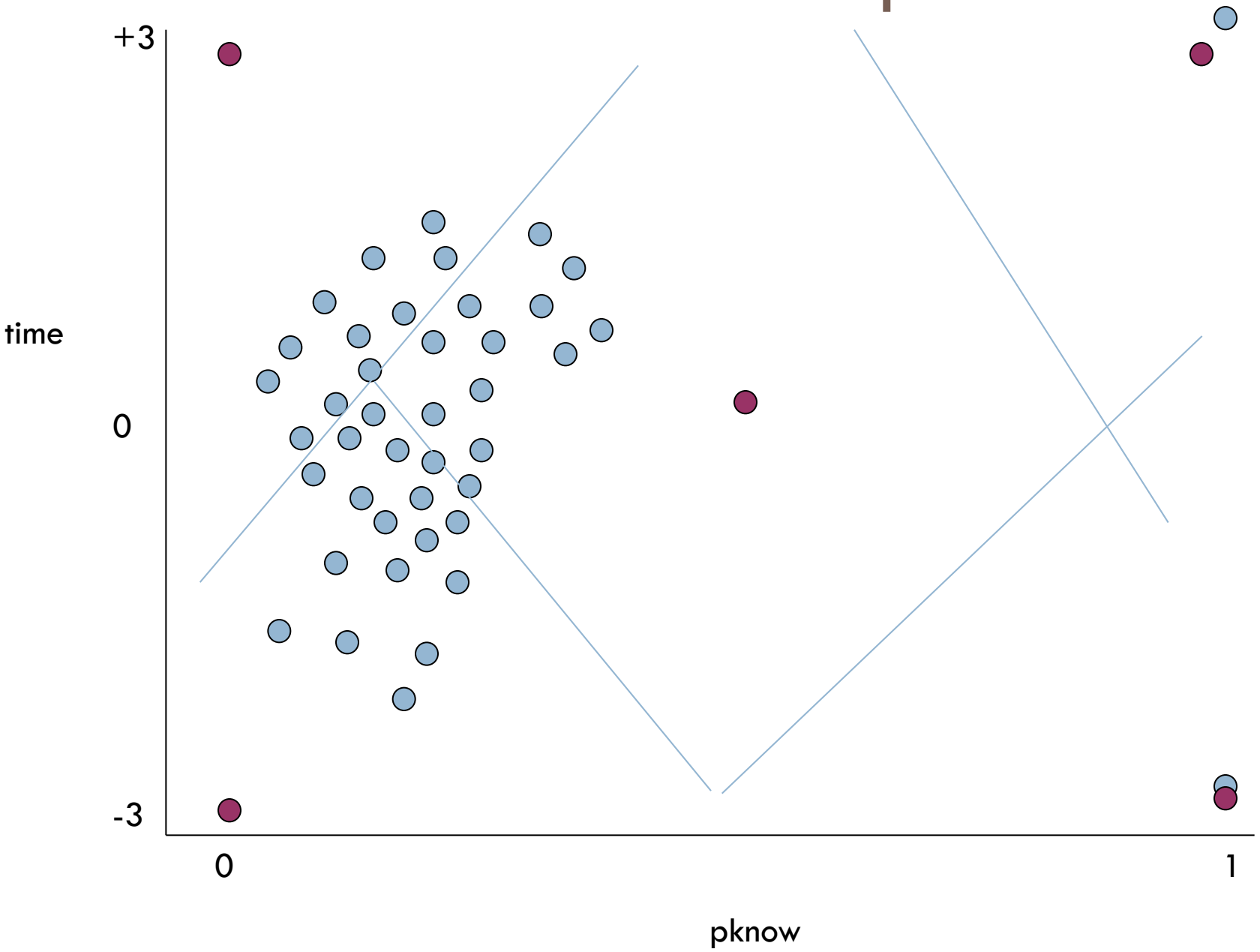
Exercise 7-1-2



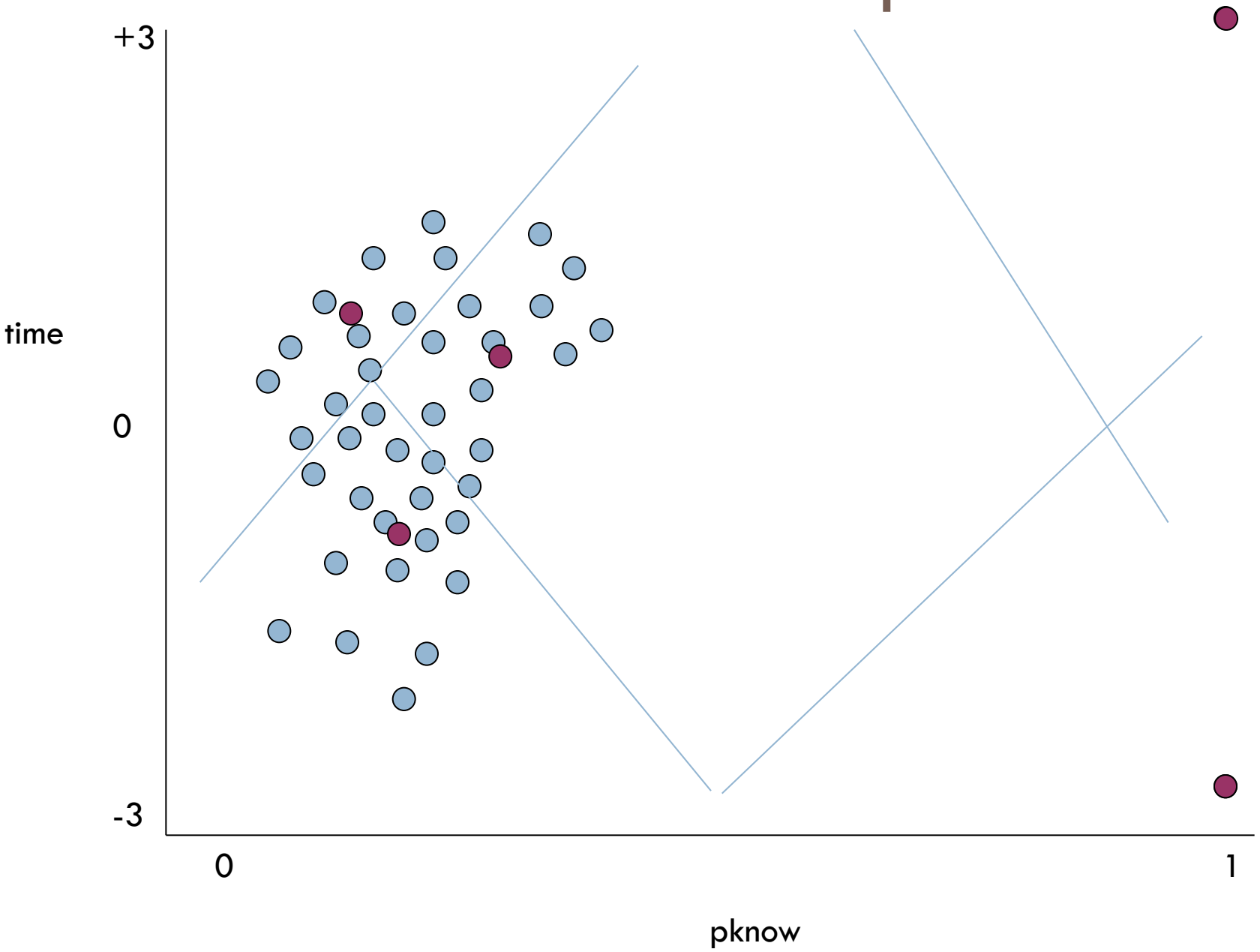
Pause Here with In-Video Quiz

- Do this yourself if you want to
- Only quiz option: go ahead

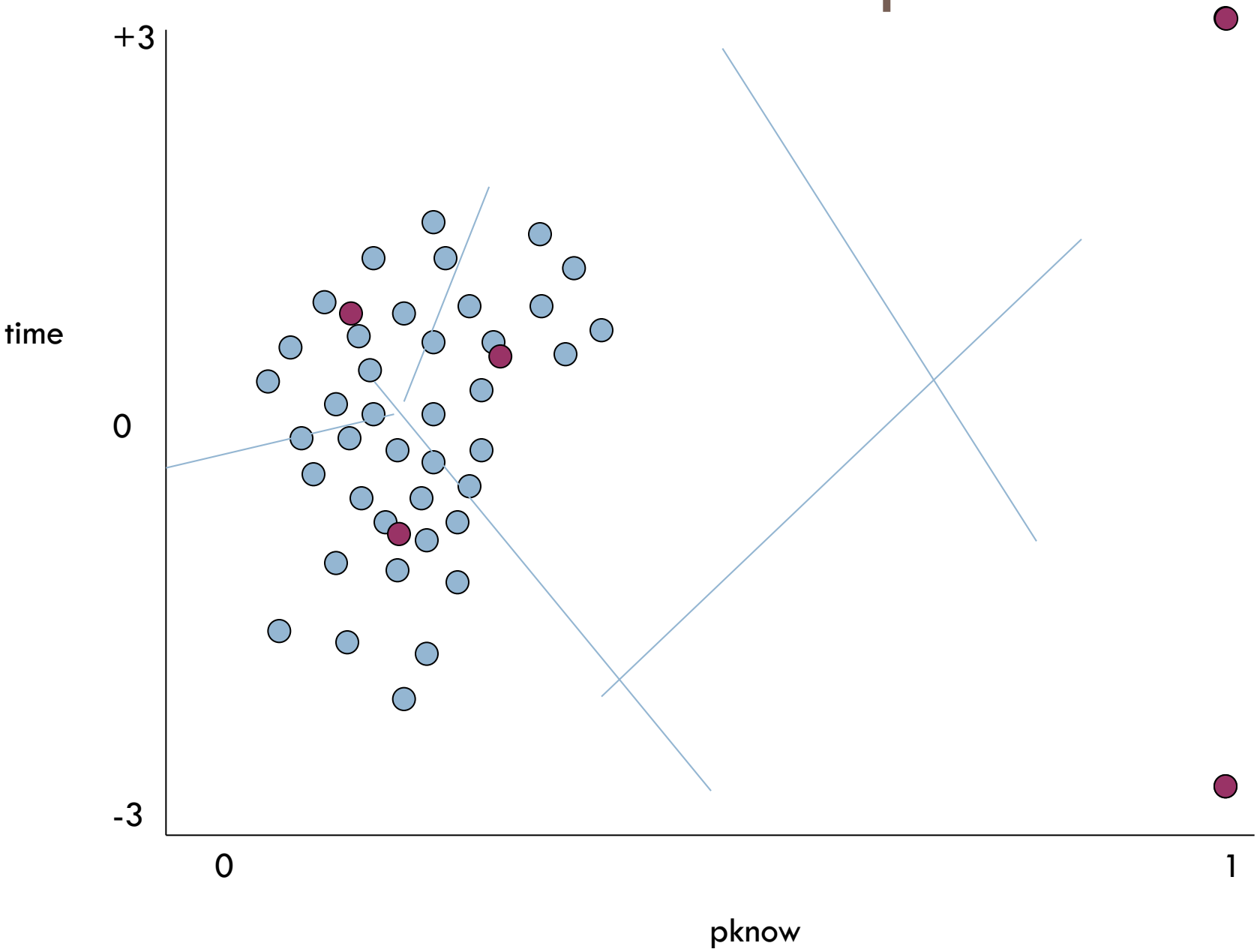
Solution Step 1



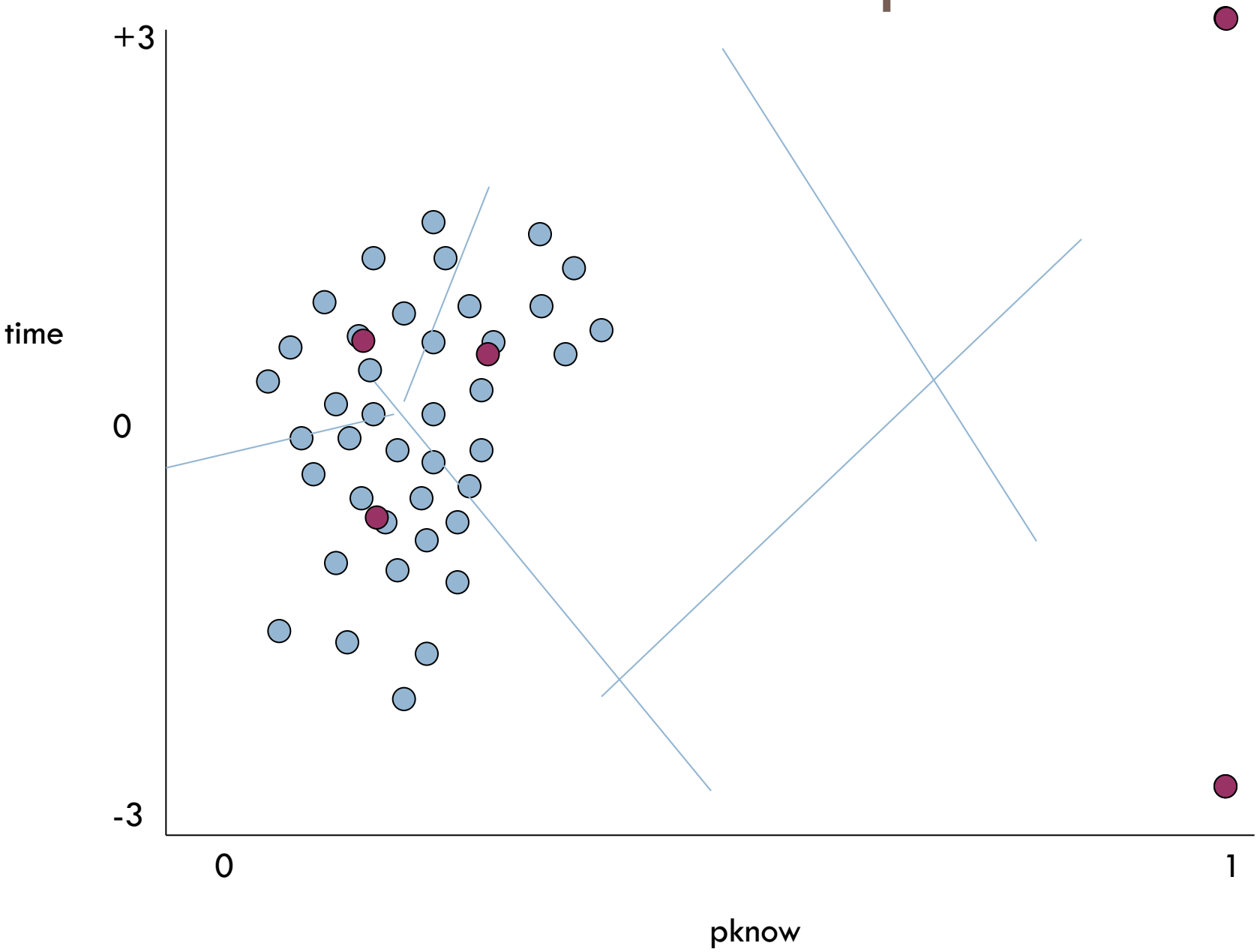
Solution Step 2



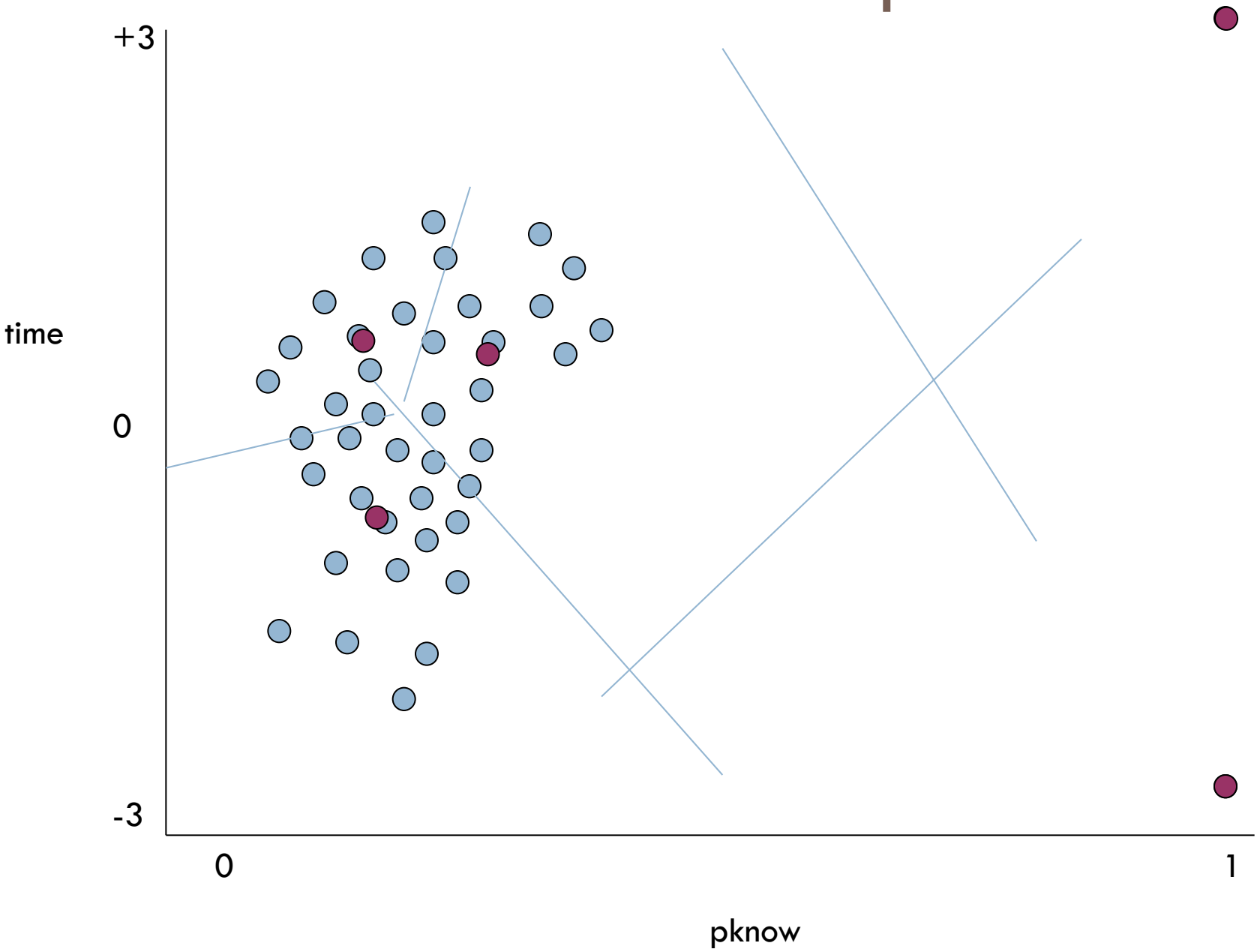
Solution Step 3



Solution Step 4



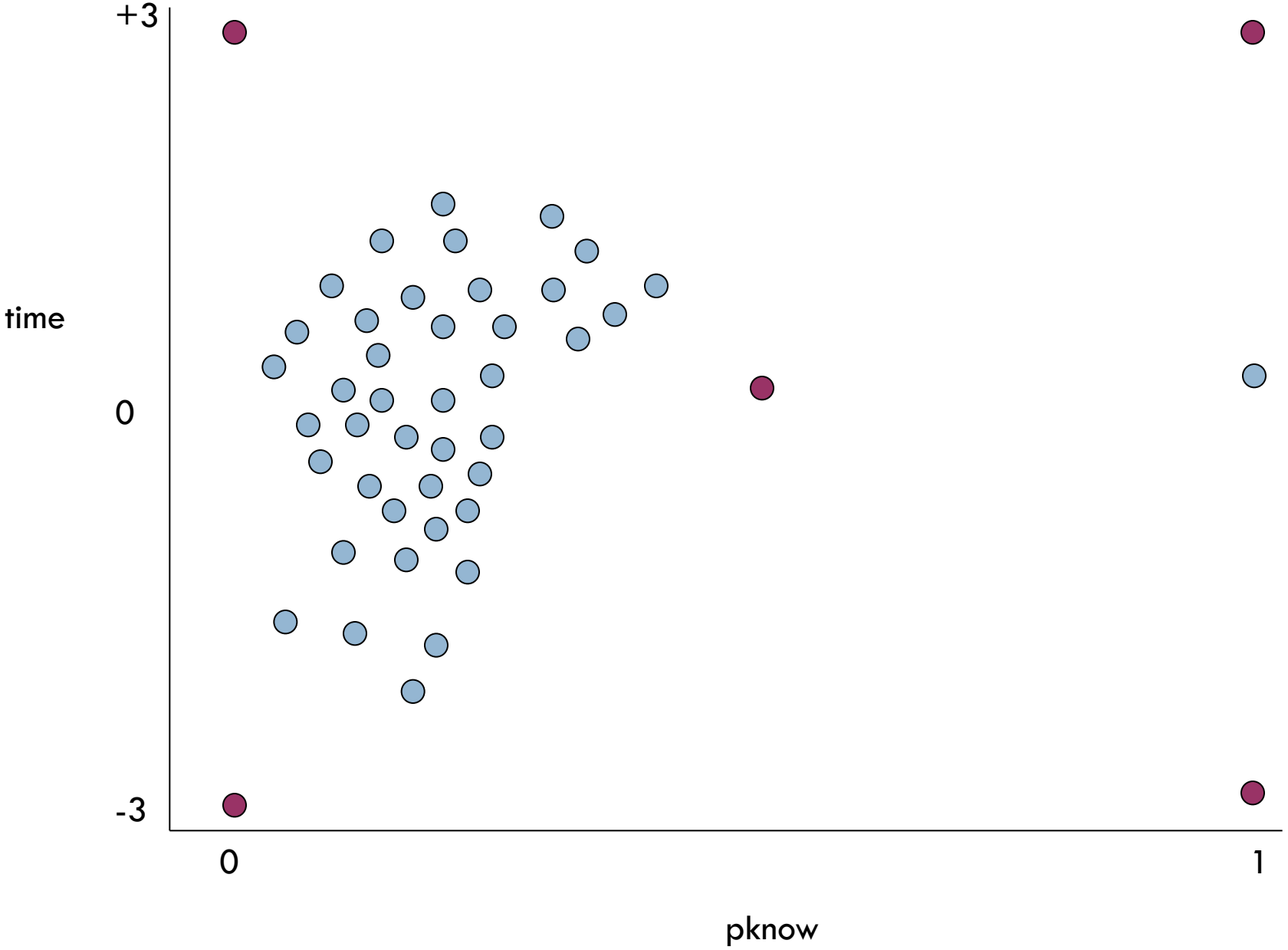
Solution Step 5



Notes

- The three clusters in the same data lump might move around for a little while
- But really, what we have here is one cluster and two outliers…
- k should be 3 rather than 5
  - See next lecture to learn more

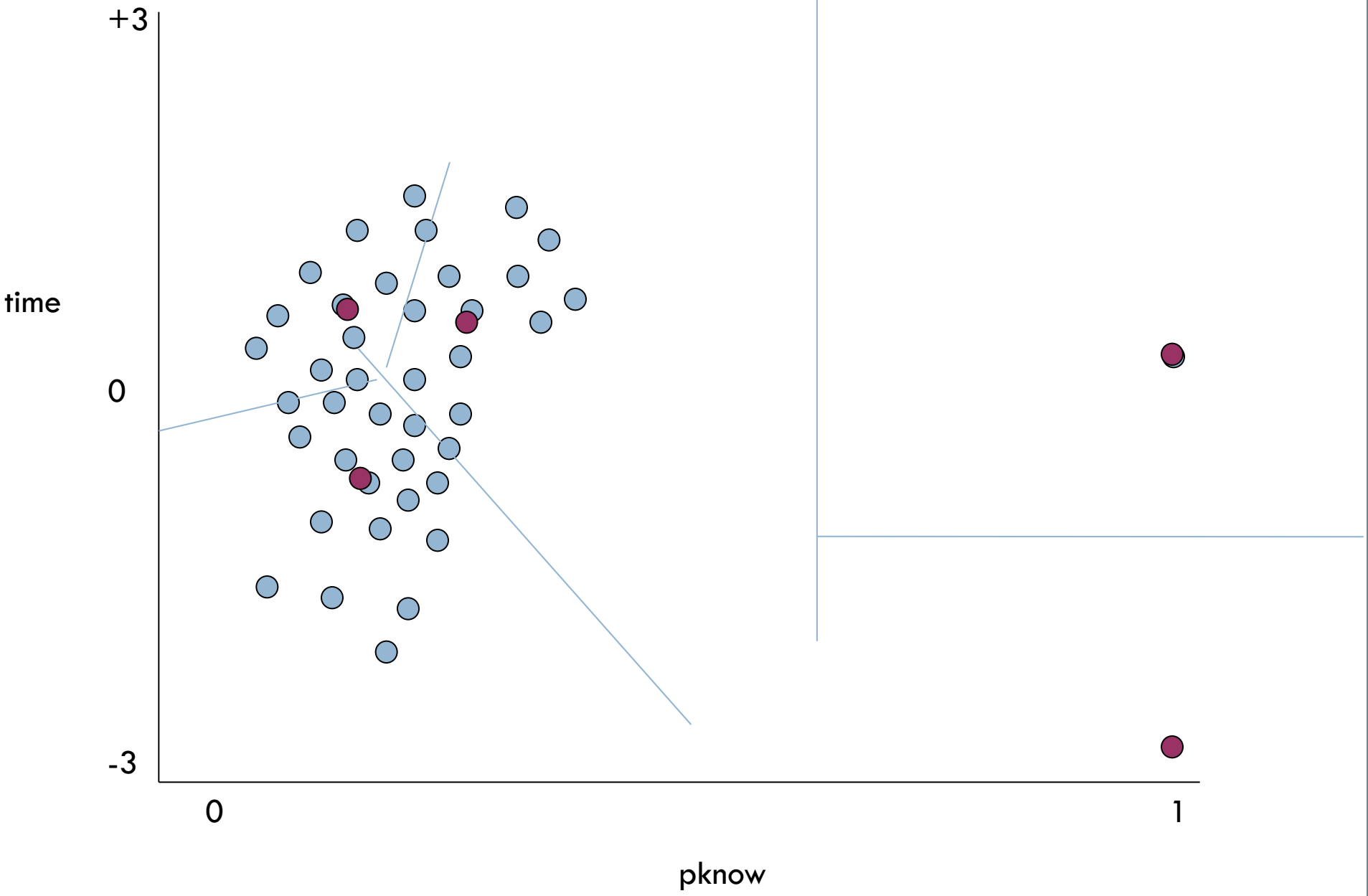
Exercise 7-1-3



Pause Here with In-Video Quiz

- Do this yourself if you want to
- Only quiz option: go ahead

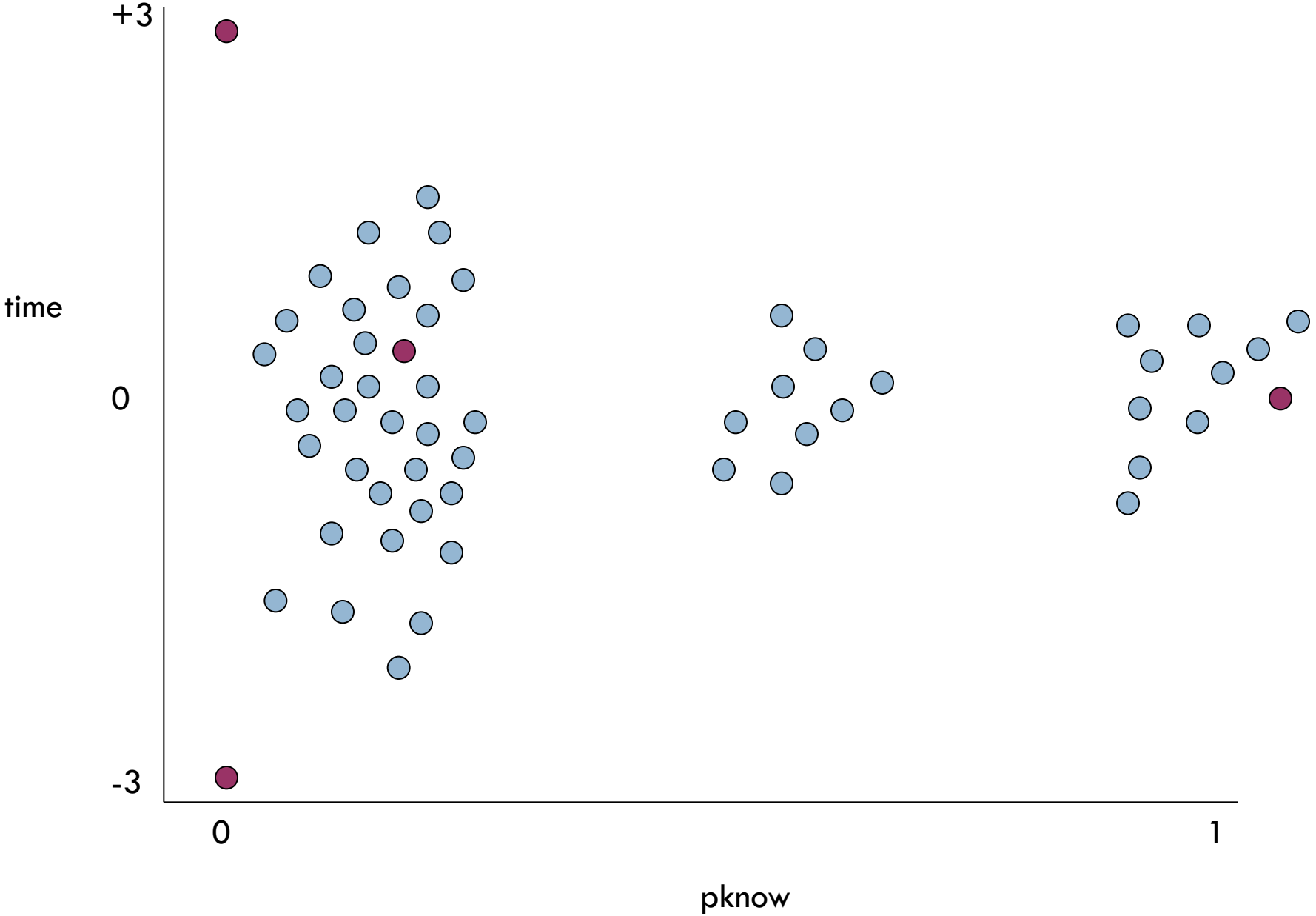
Solution



Notes

- The bottom-right cluster is actually empty!
- There was never a point where that centroid was actually closest to any point

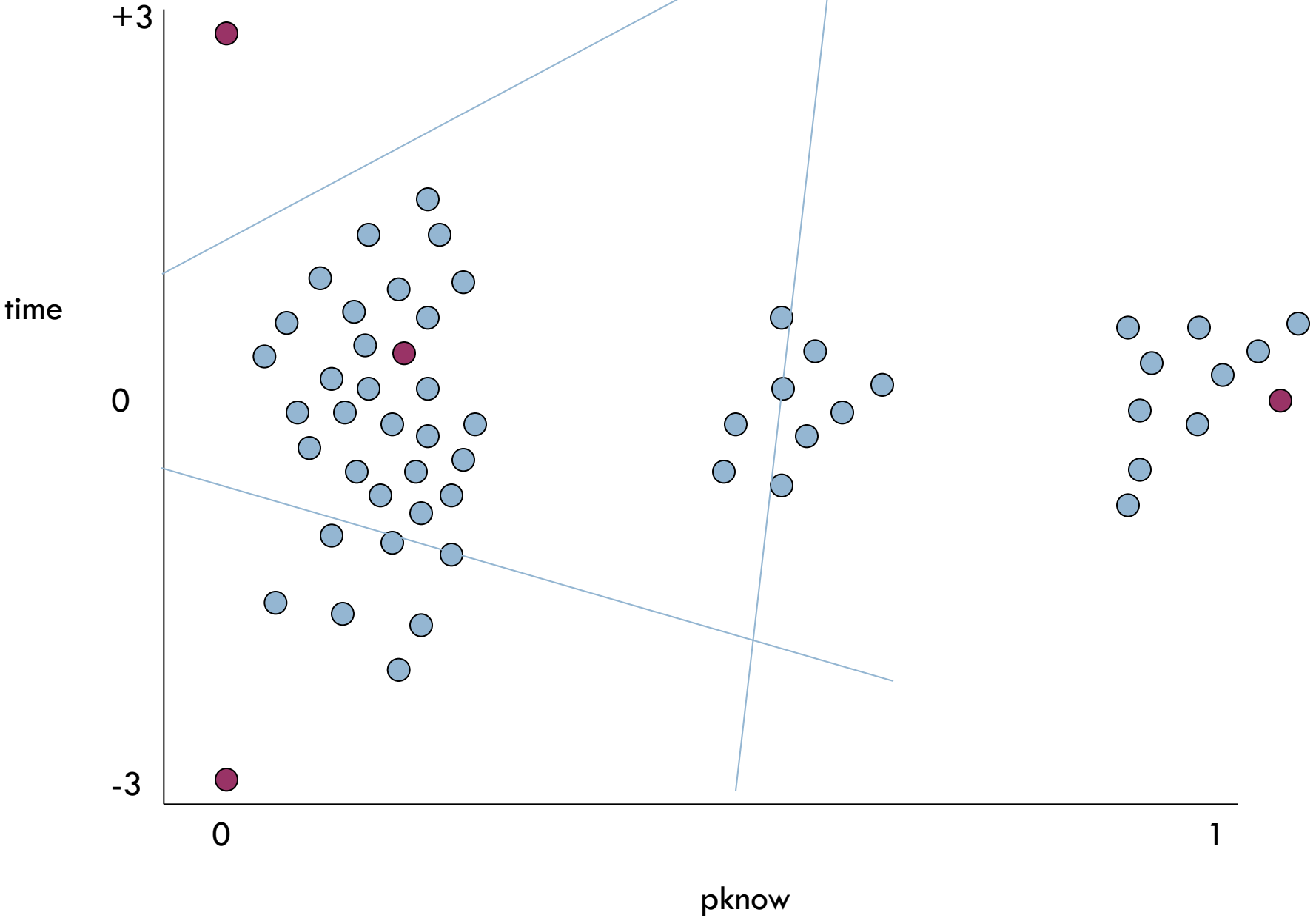
Exercise 7-1-4



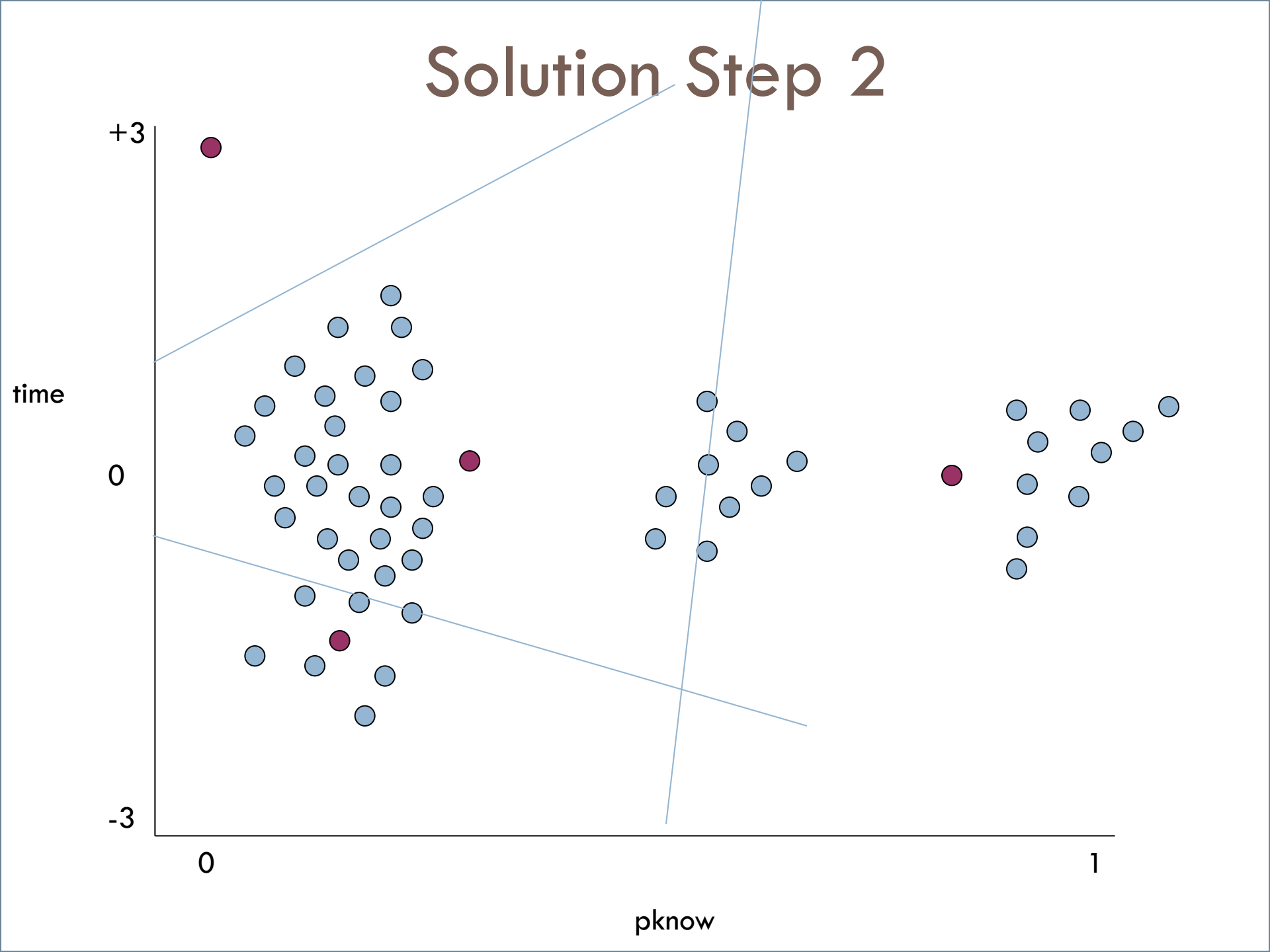
Pause Here with In-Video Quiz

- Do this yourself if you want to
- Only quiz option: go ahead

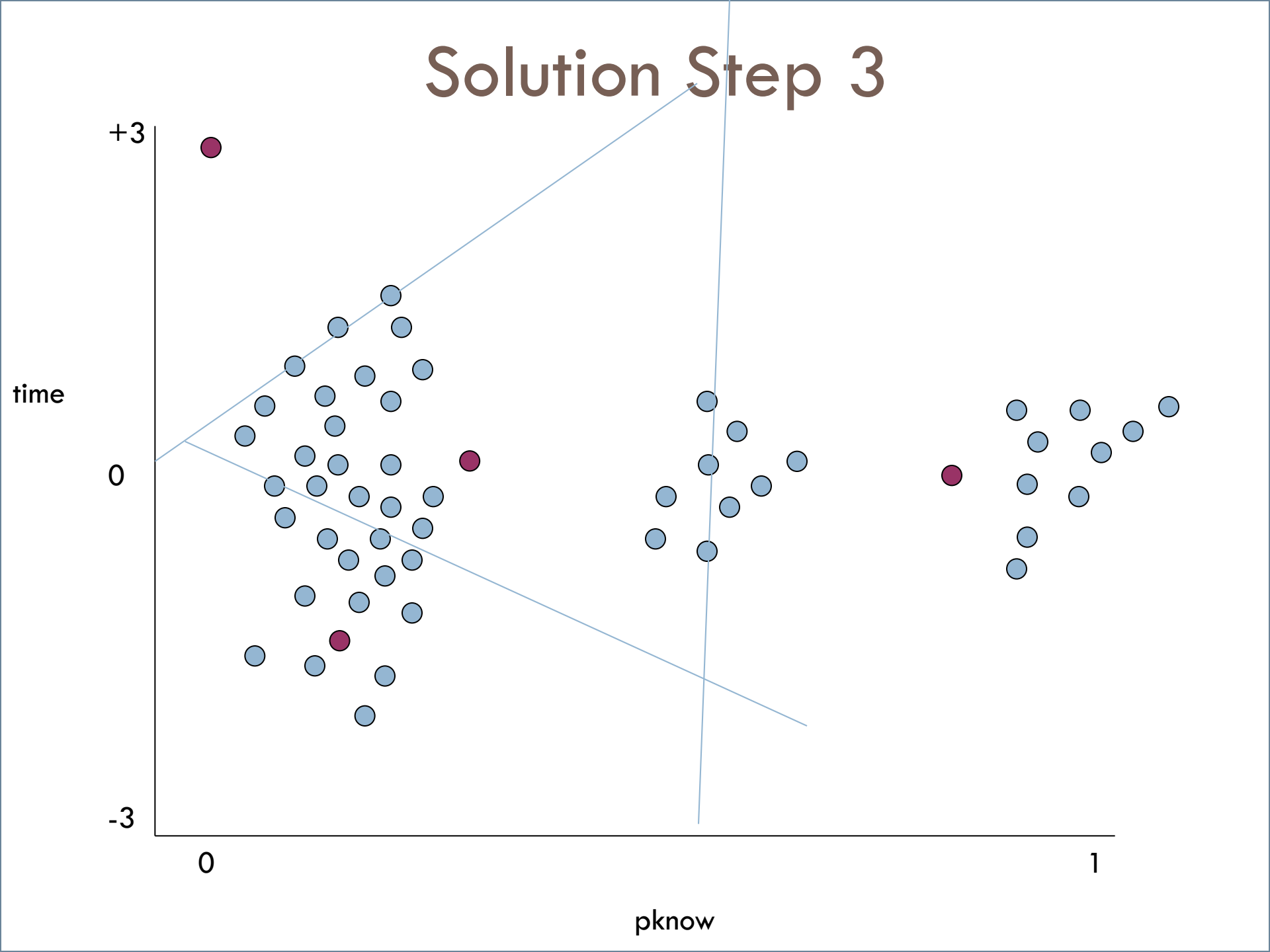
Solution Step 1



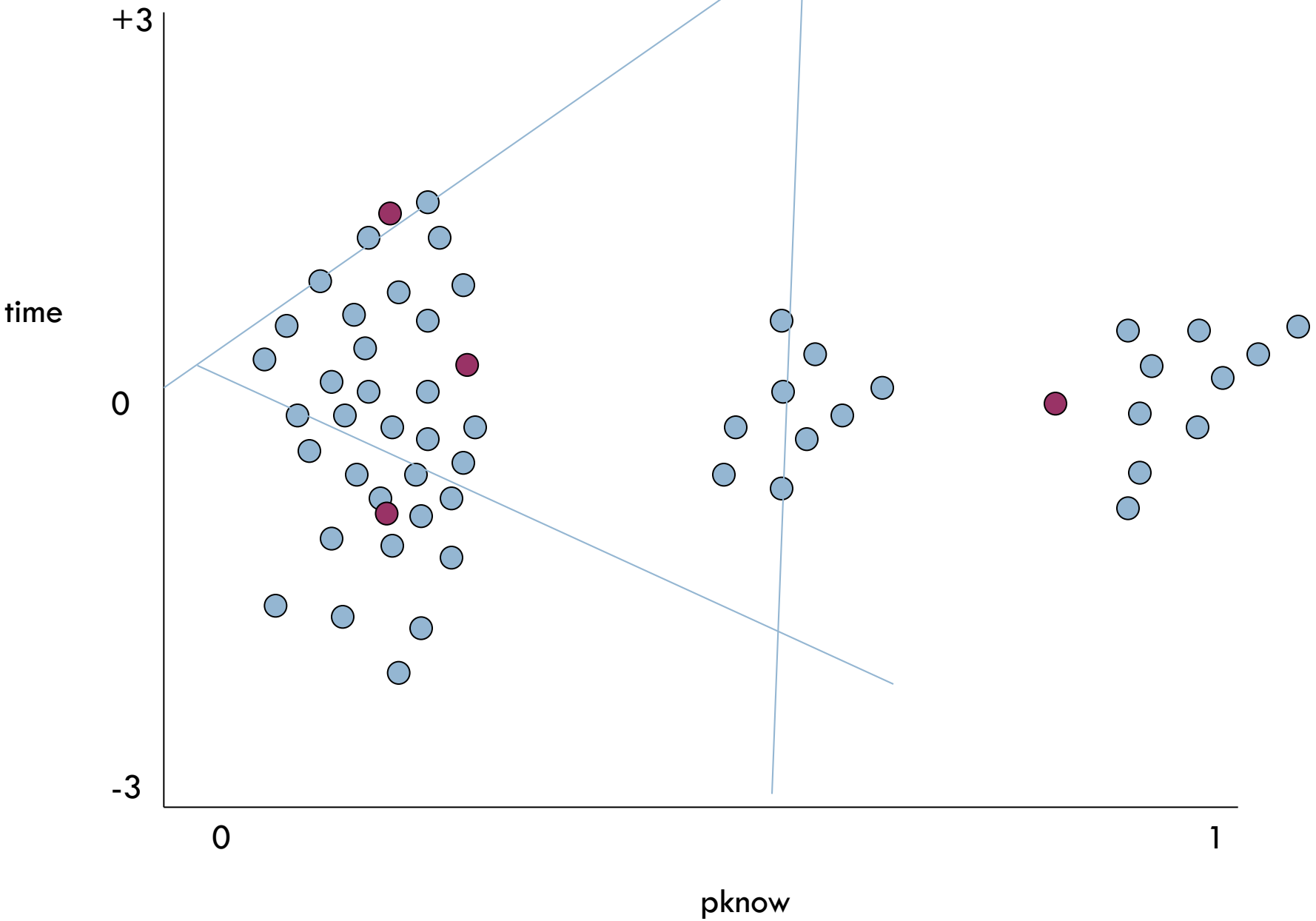
Solution Step 2



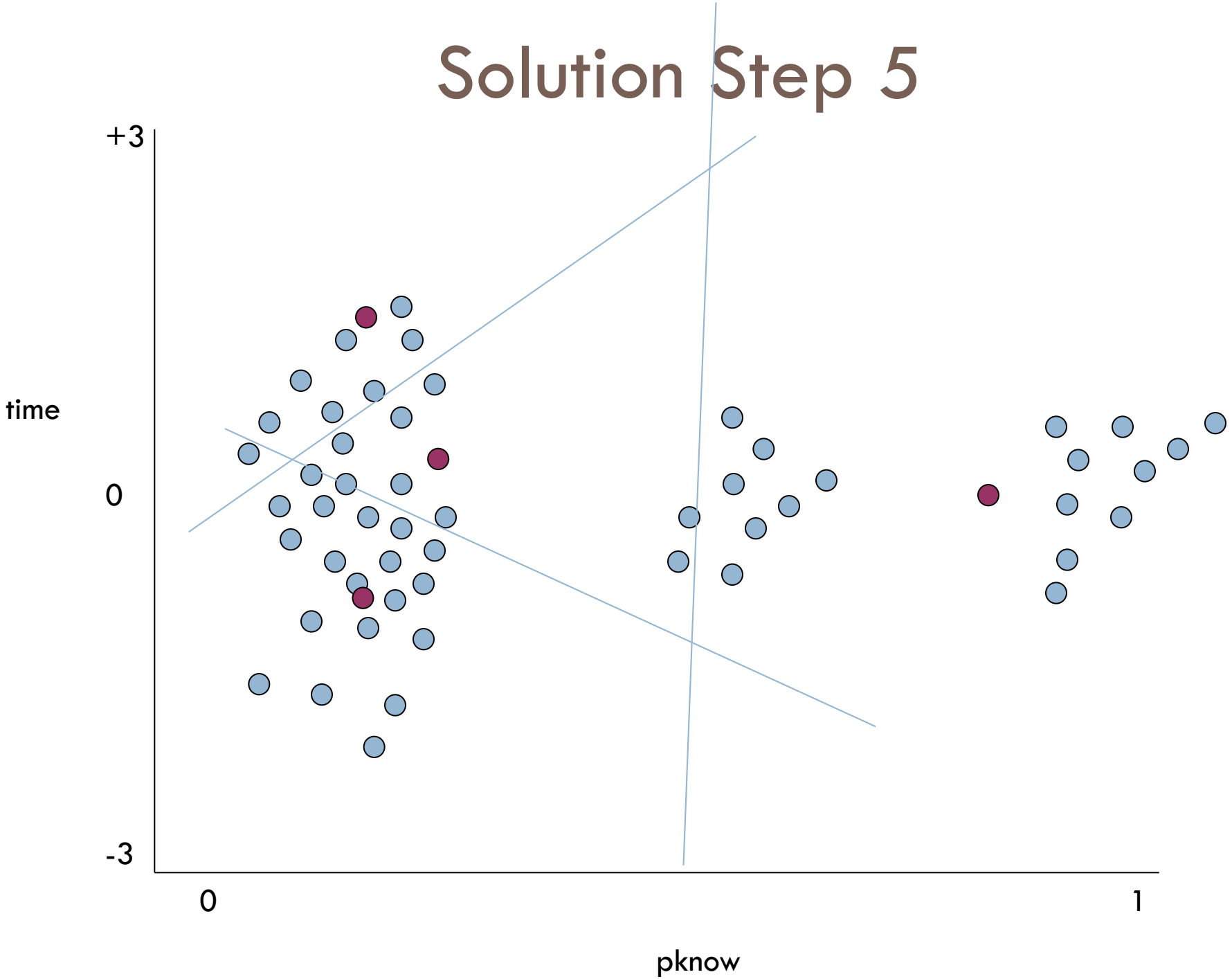
Solution Step 3



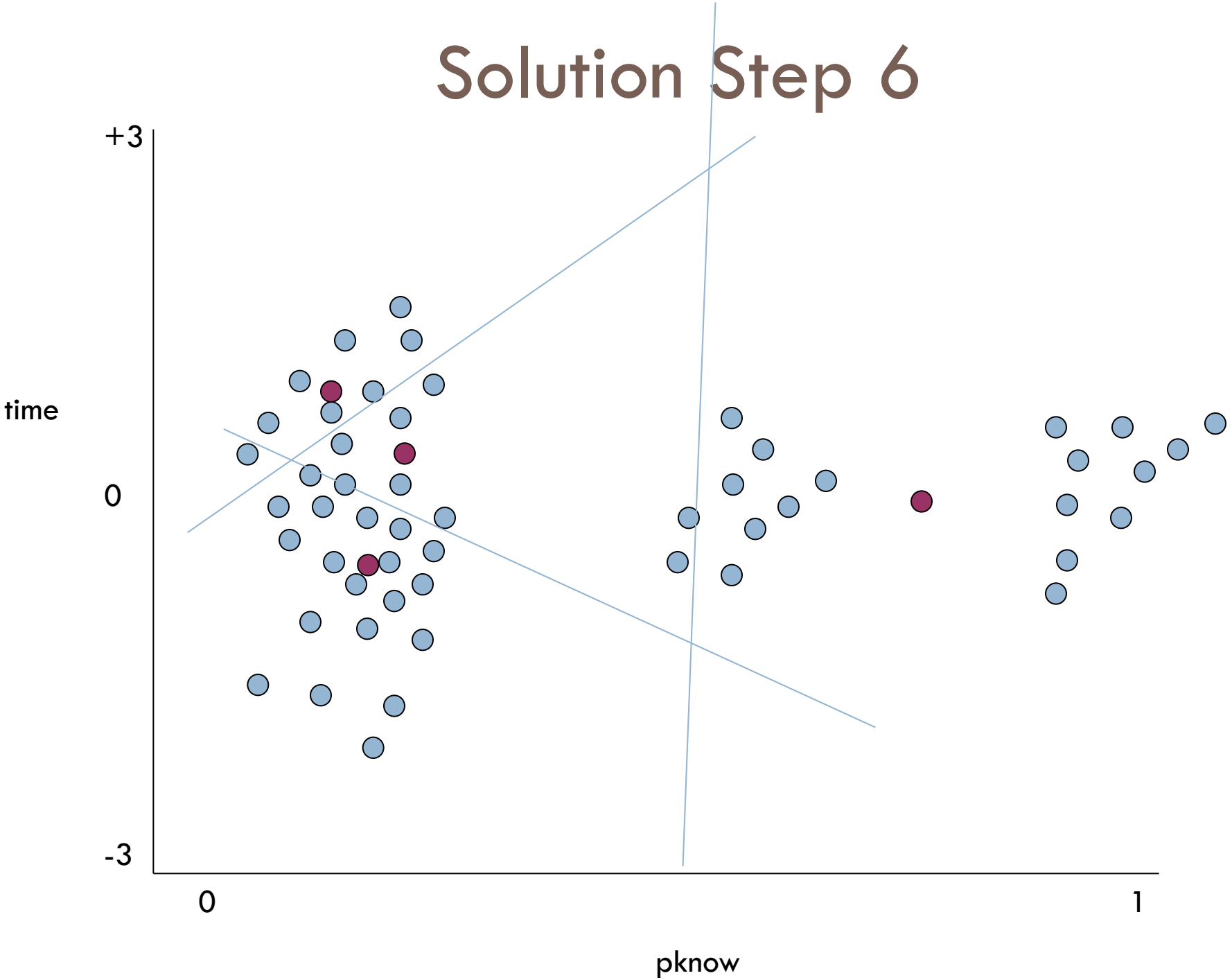
Solution Step 4



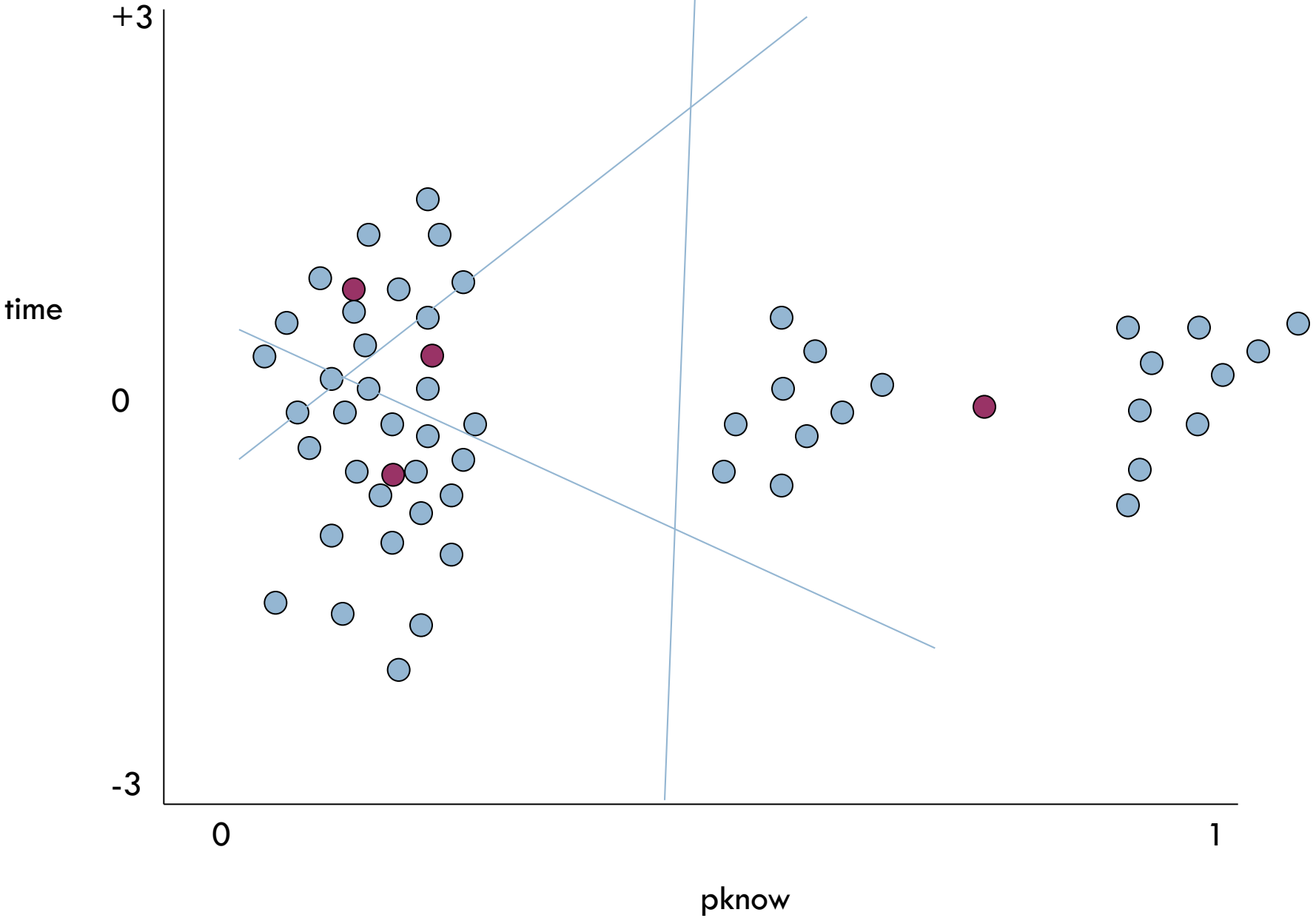
Solution Step 5



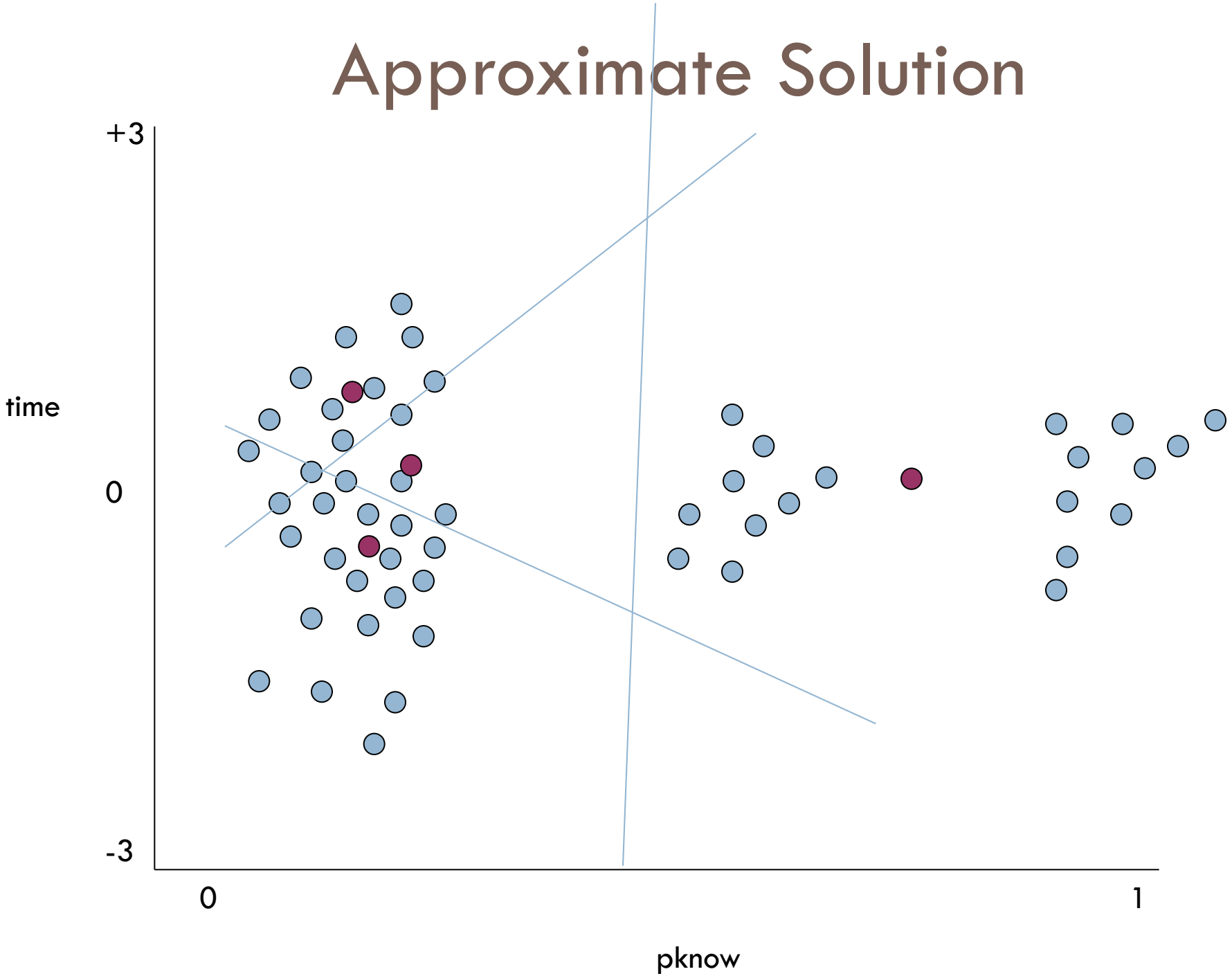
Solution Step 6



Solution Step 7



Approximate Solution

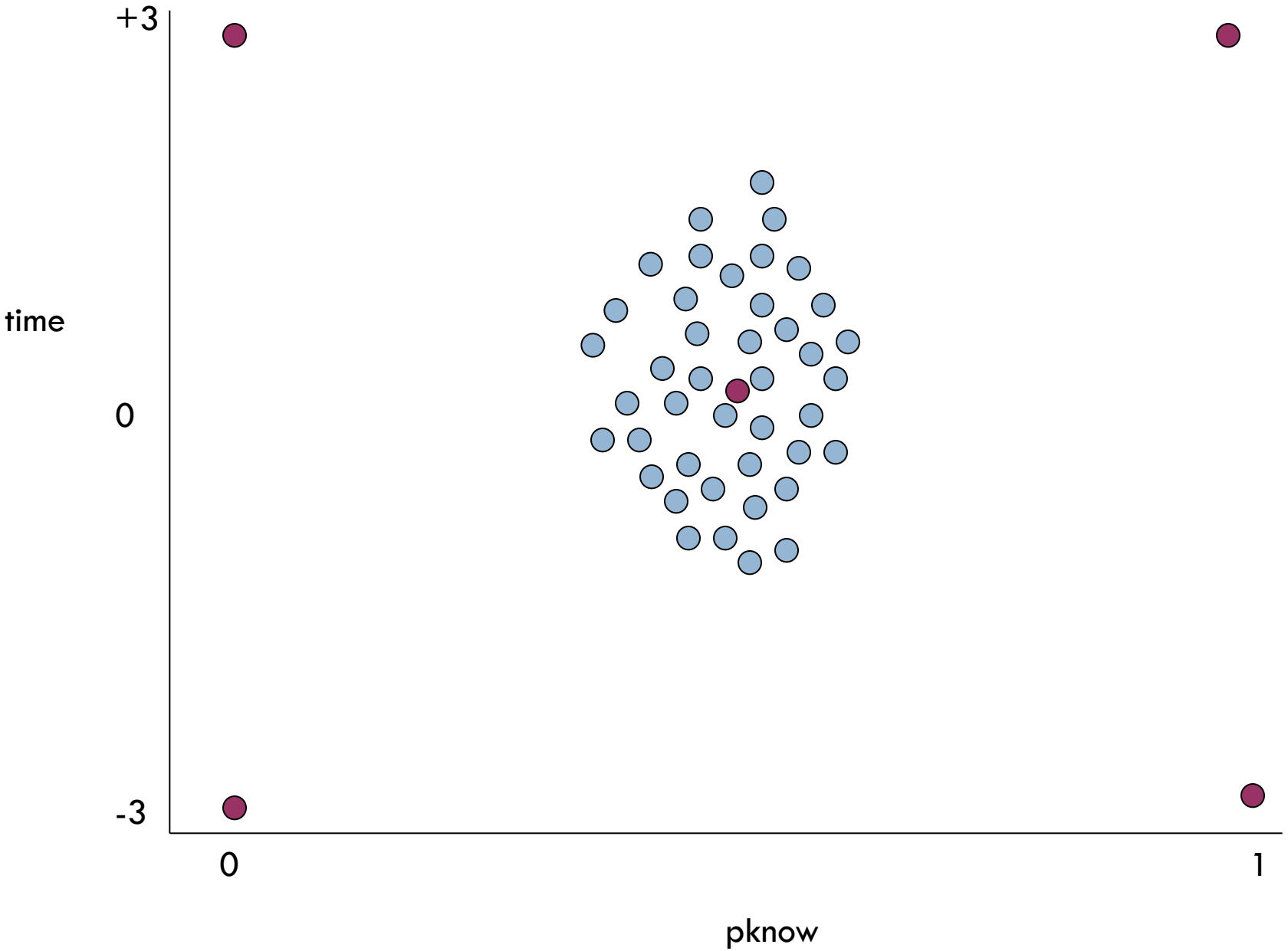


Notes

- Kind of a weird outcome

- By unlucky initial positioning
  - One data lump at left became three clusters
  - Two clearly distinct data lumps at right became one cluster

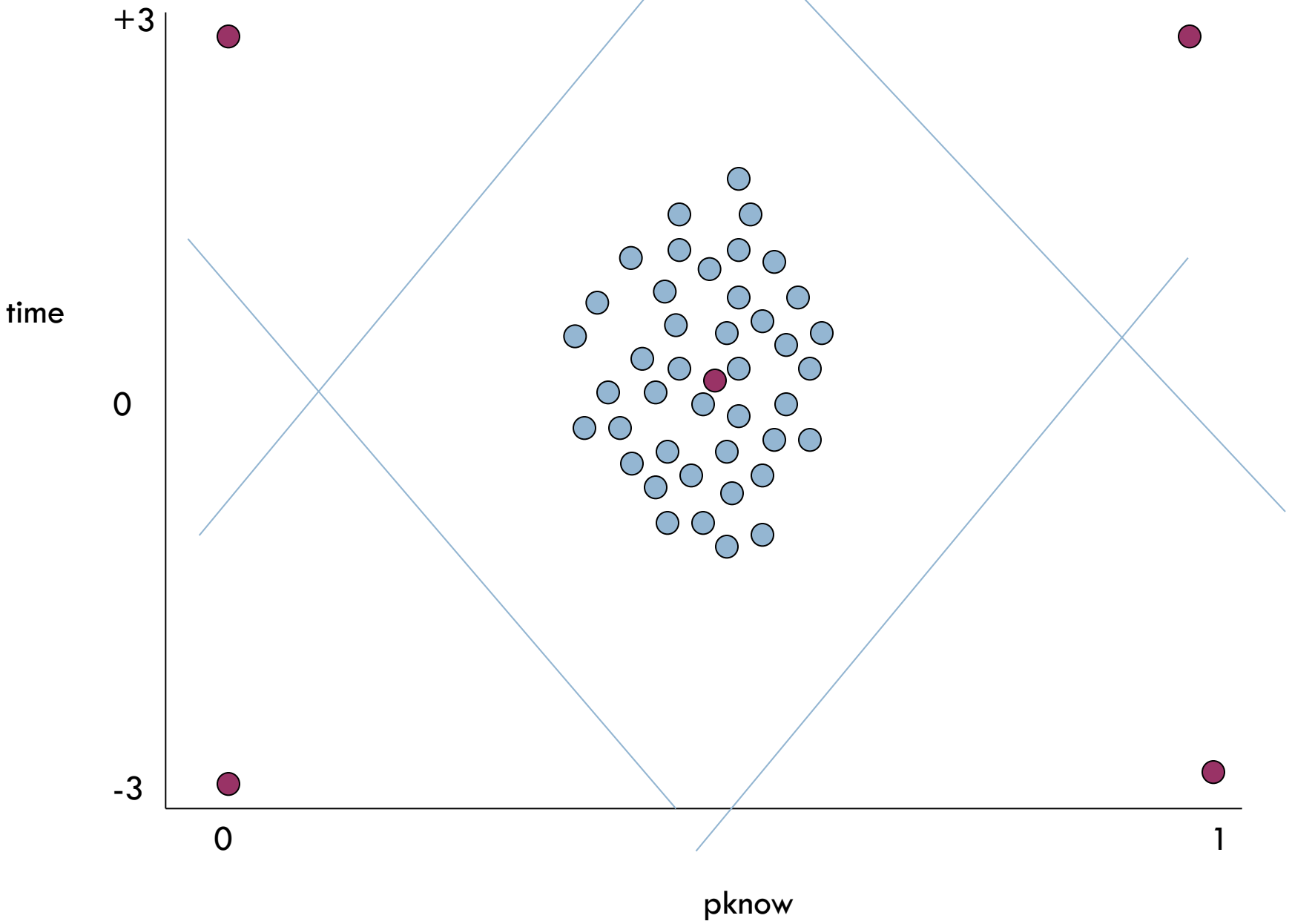
Exercise 7-1-5



Pause Here with In-Video Quiz

- Do this yourself if you want to
- Only quiz option: go ahead

Exercise 7-1-5



Notes

- That actually kind of came out ok…

As you can see

- A lot depends on initial positioning
- And on the number of clusters

- How do you pick which final position and number of clusters to go with?

Next lecture

- Clustering – Validation and Selection of k