TRIP/STOP Detection in GPS Traces to Feed Prompted Recall Survey

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Hasselt University - IMOB

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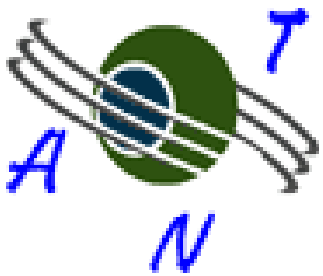

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Overview

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Introduction

1. Determine stops from *person traces* (as opposed to vehicle traces)
2. To use in a *prompted recall* study
3. Sensitivity analysis to find the best values for parameters

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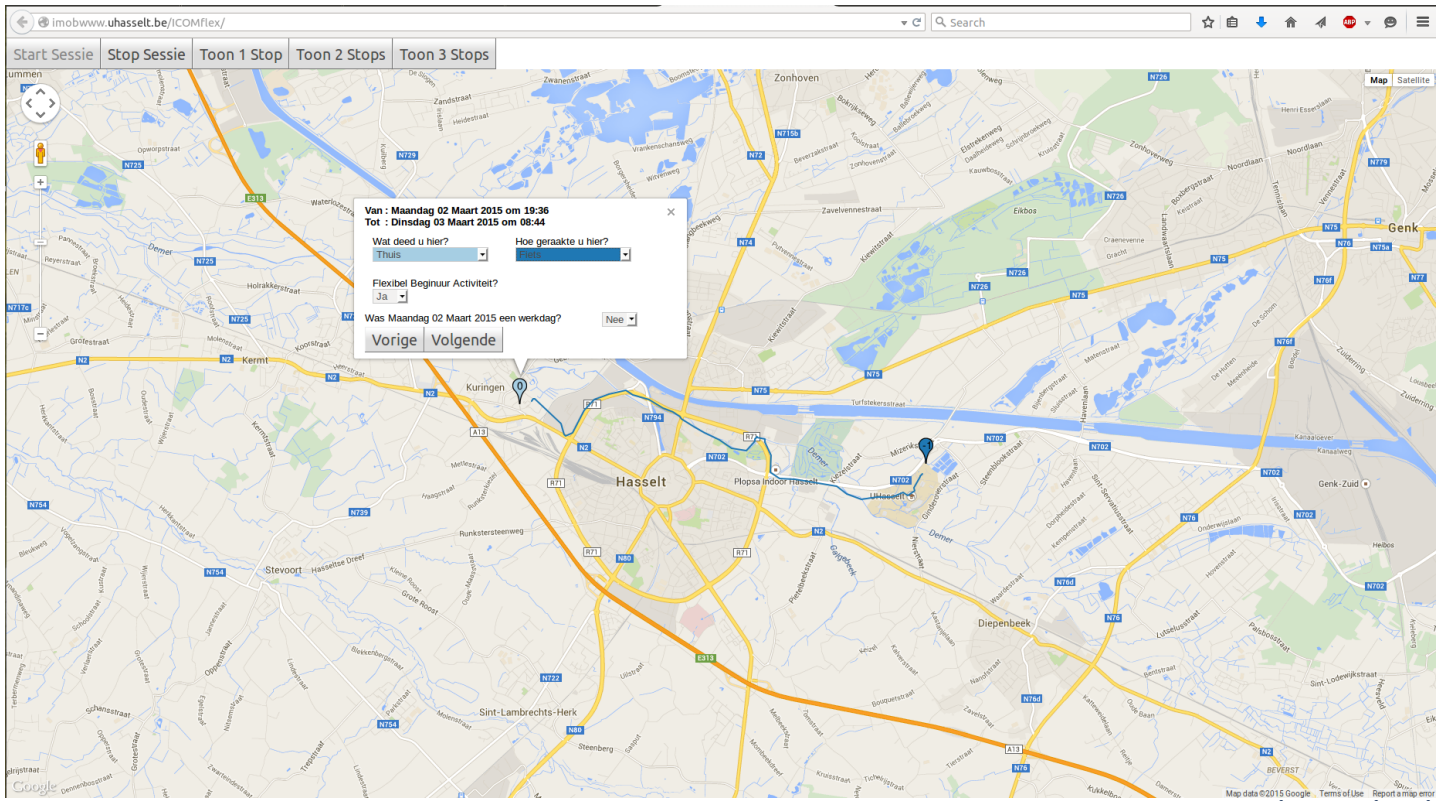
Introduction: Prompted Recall



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Overview

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Working: Brief

1. Find *stop clusters*
   - Points that are close together in time and space
2. Every point between two stops might be part of a *trip*
3. Some validity checks for both trips and stops

Terminology: Concepts & Variables

1. Concept
   - *Cluster center*: the center of the stop cluster
     - Shifts when a point falls out the radius of the stop cluster
   - *Potential stop points*: points that might be part of a stop
   - *Potential trip points*: points that might be part of a trip
2. Variable
   - *Stop Duration threshold*: minimum duration a person needs to stay in a specific area in order to qualify the area as a stop
   - *Stop Distance threshold*: size of the area where a person needs to stay in order to qualify the area as a stop
3. $\rightarrow$ A person stops when (s)he stays within the *Distance threshold* for the *Duration threshold* amount of time

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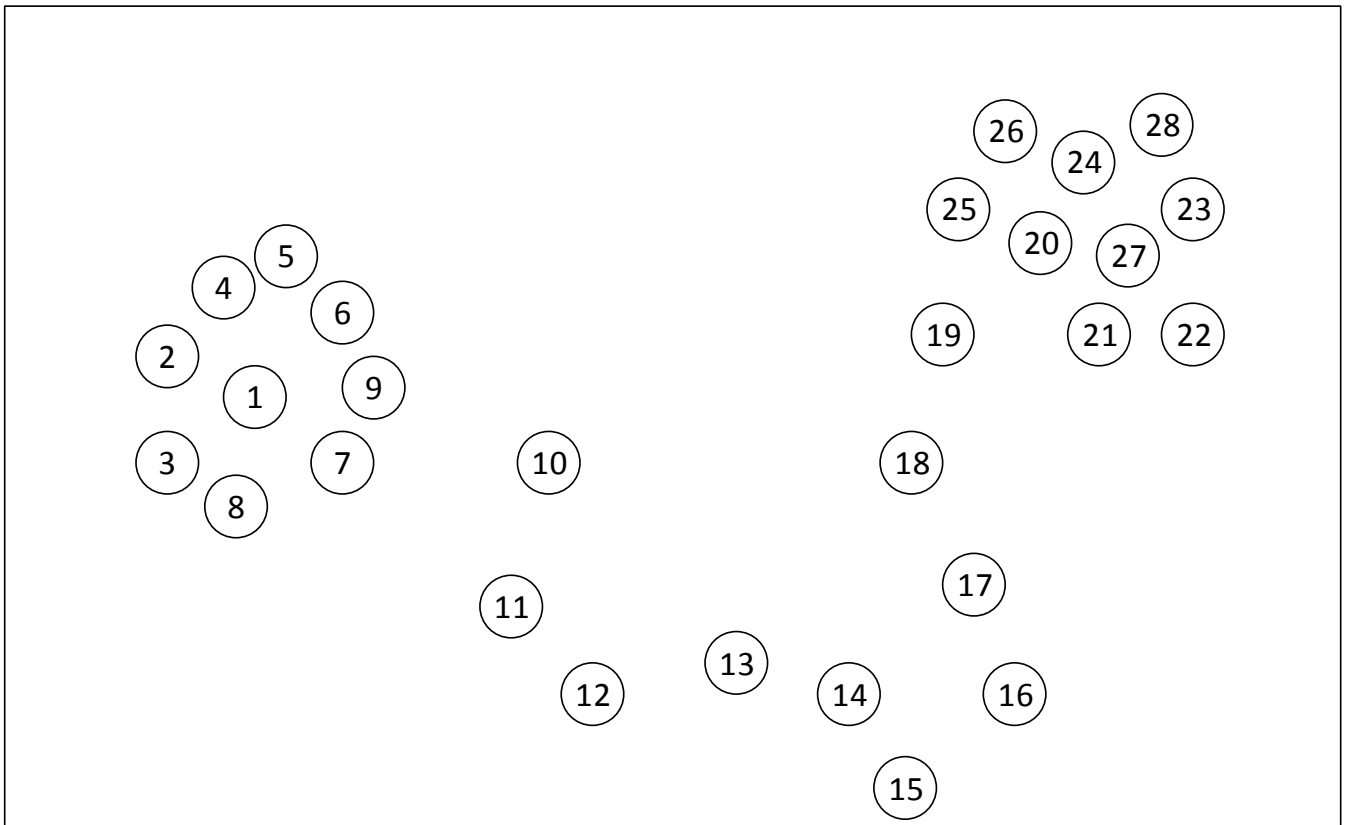
Example: Stop Detector



Cluster Center : {}
Potential Stop Points : {}
Potential Trip Points : {}

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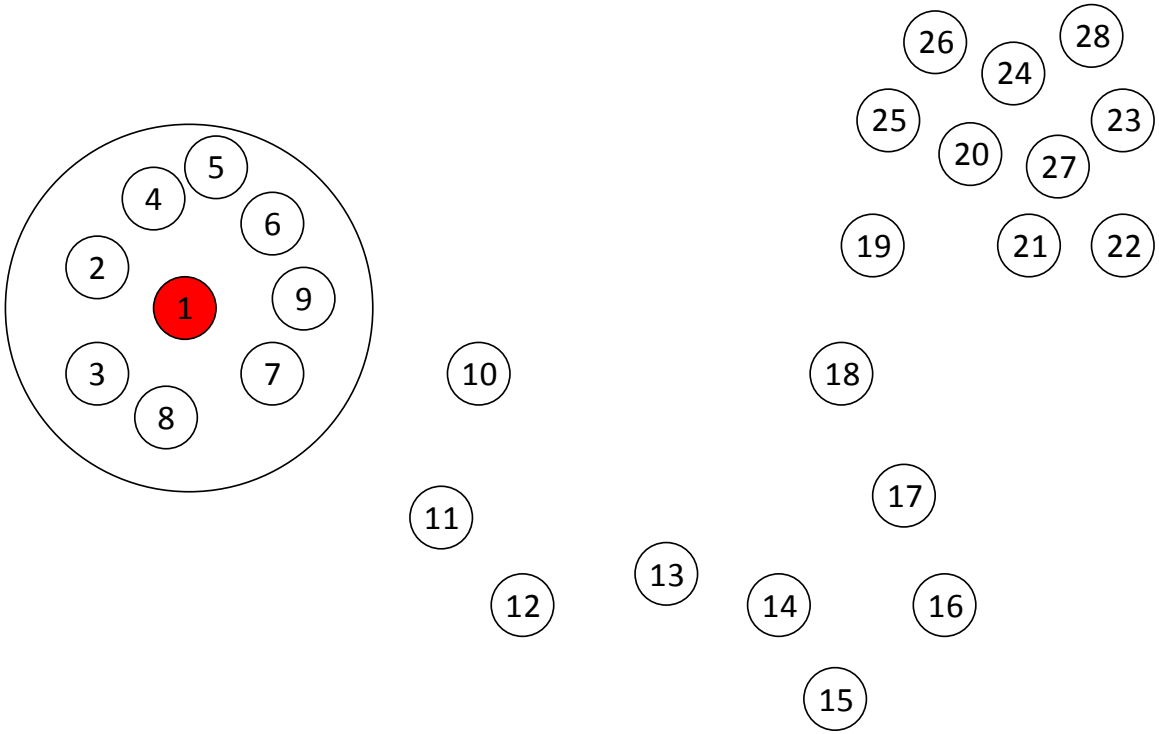
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1}
Potential Trip Points : {}

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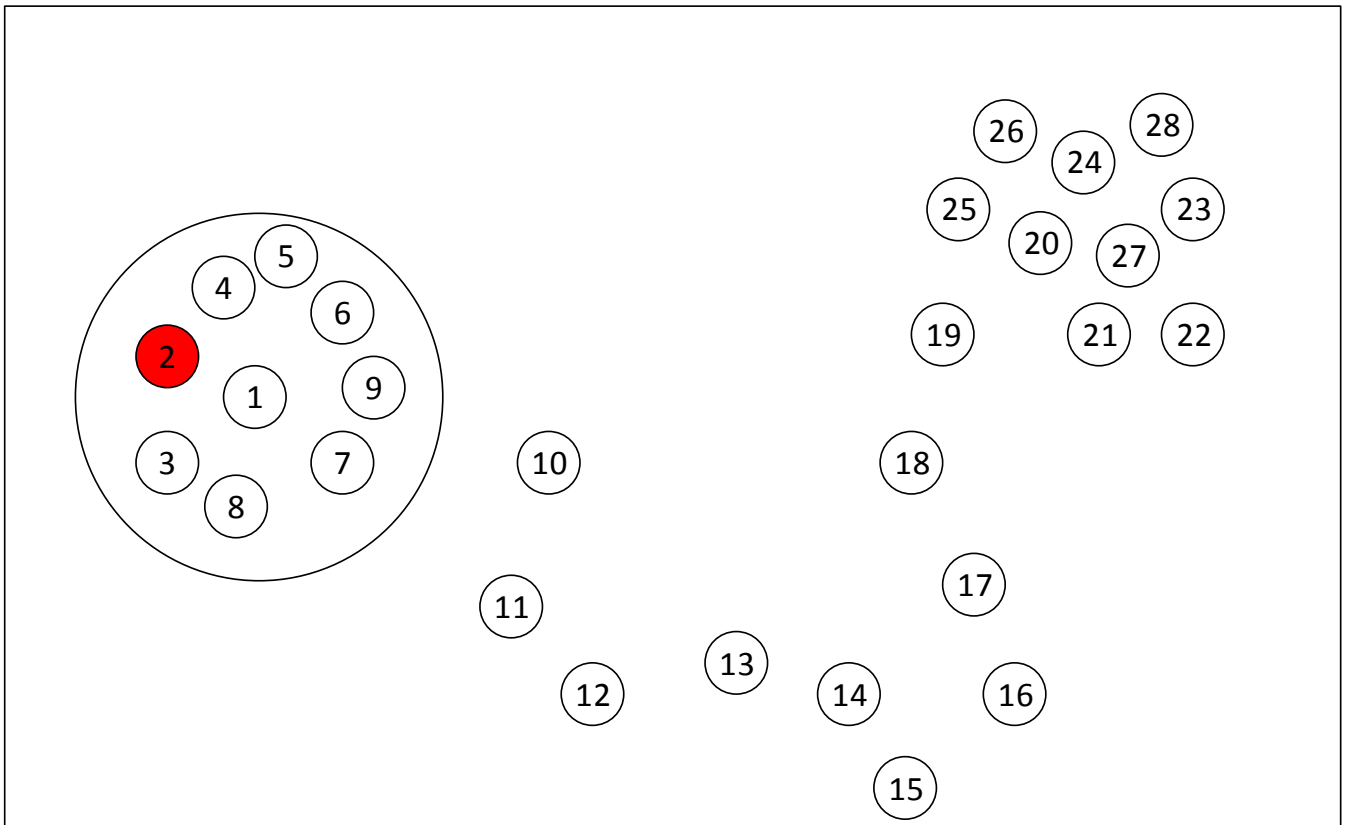
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2}
Potential Trip Points : {}

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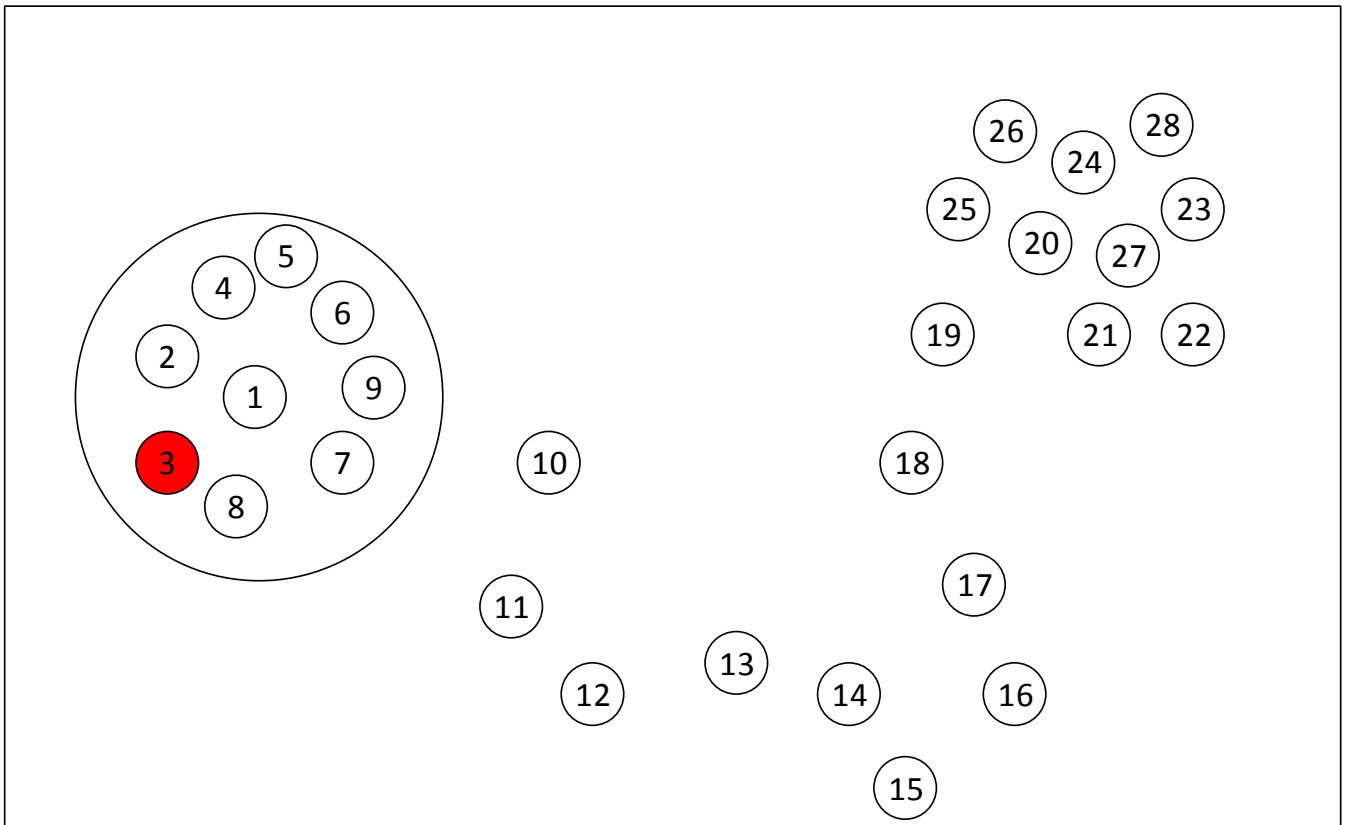
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3}
Potential Trip Points : {}

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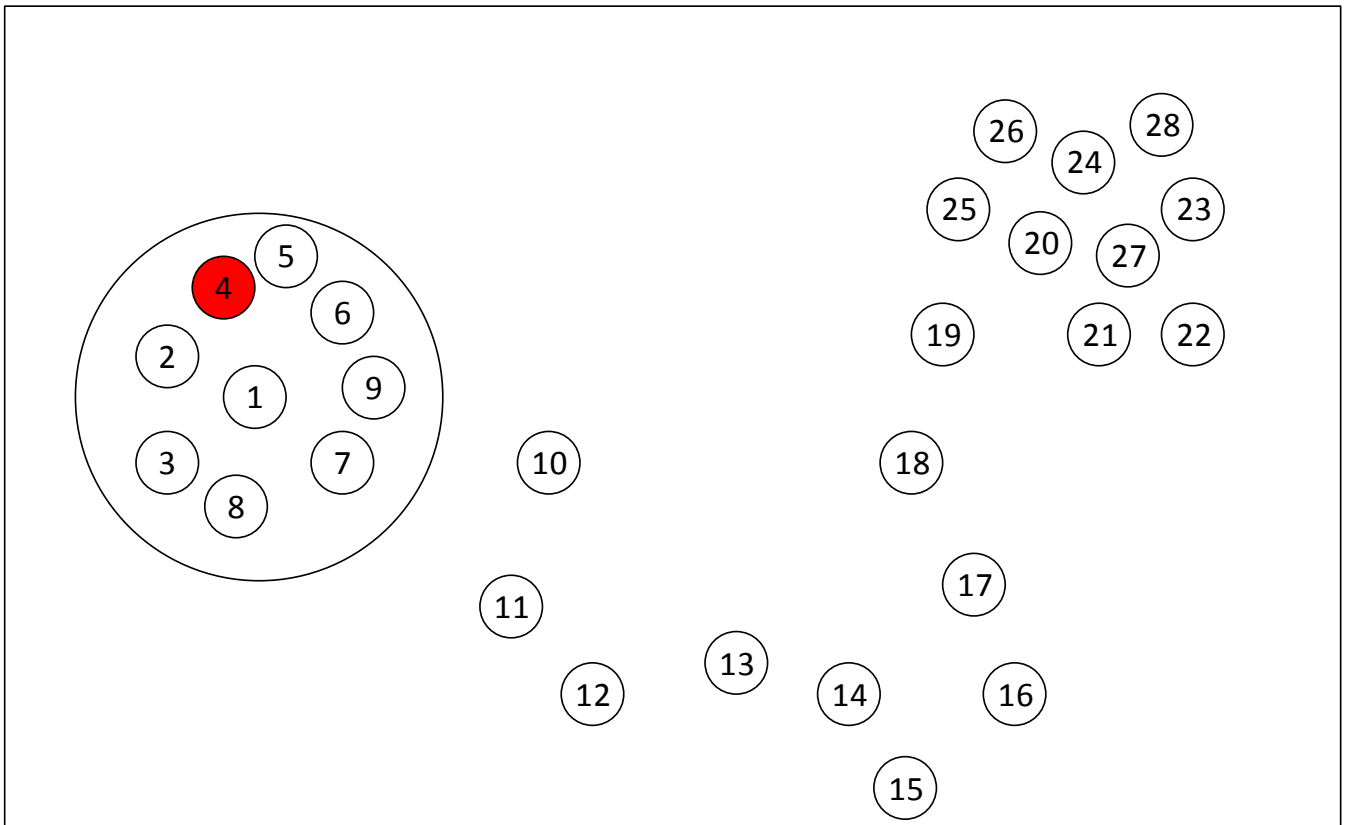
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4}
Potential Trip Points : {}

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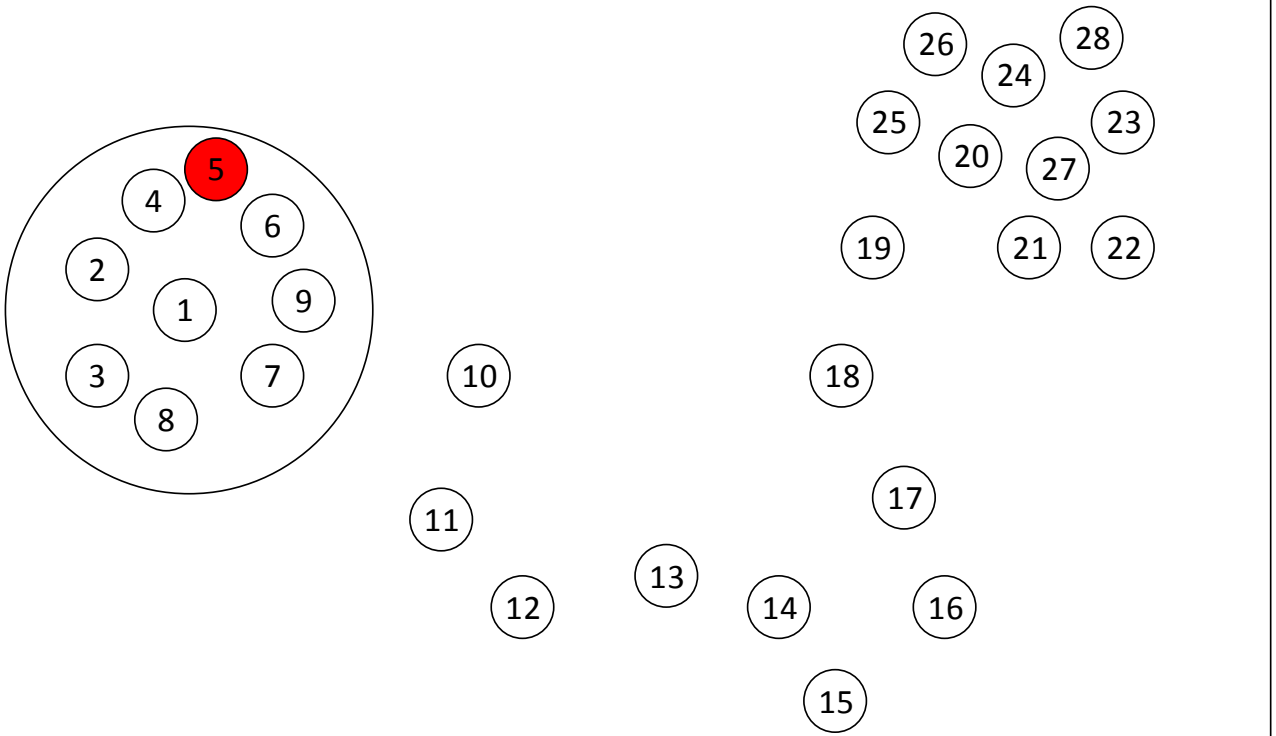
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4,5}
Potential Trip Points : {}

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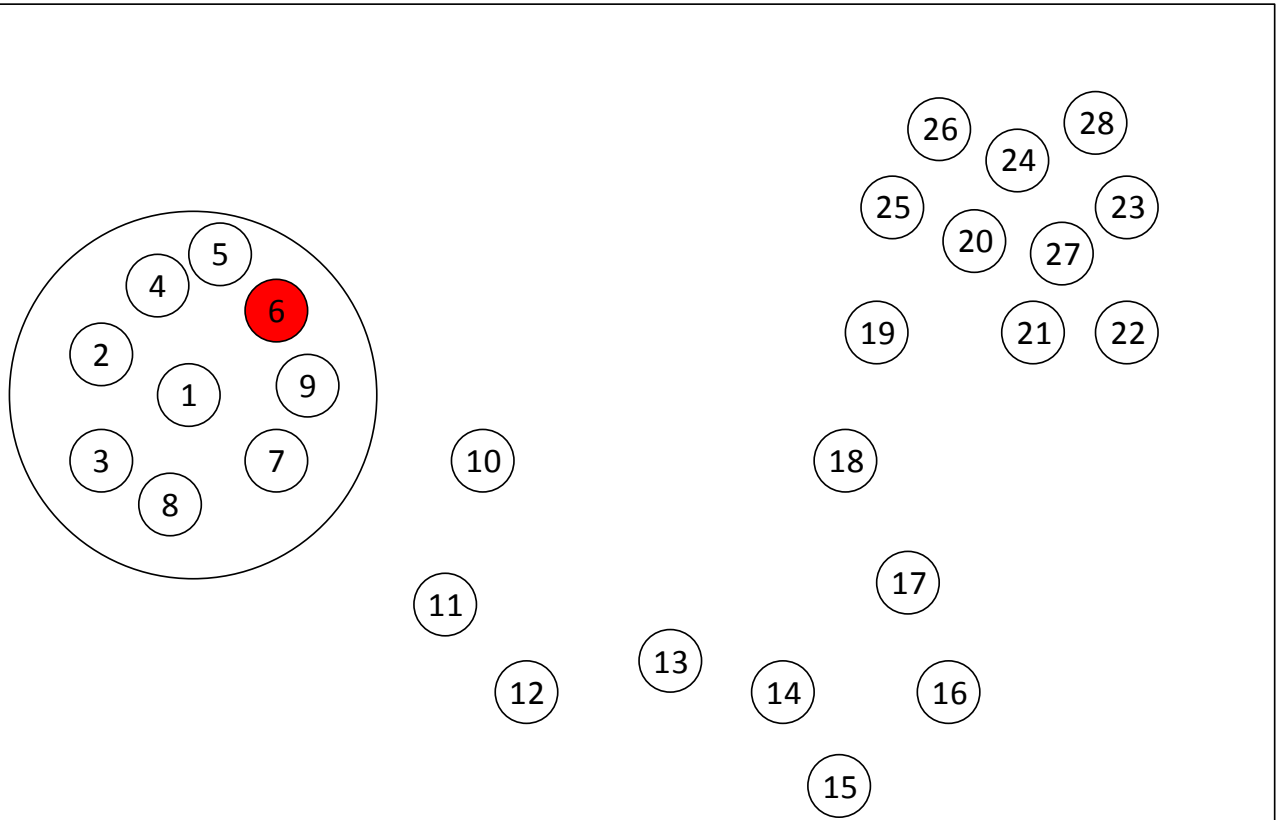
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4,5,6}
Potential Trip Points : {}

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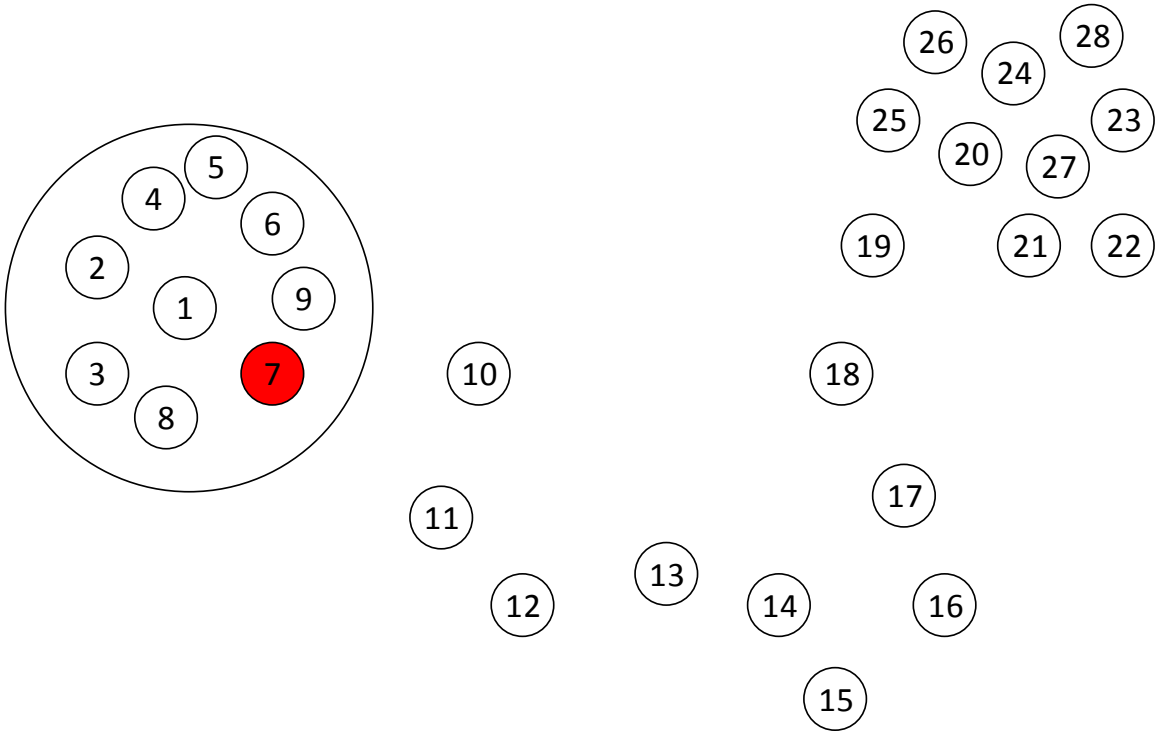
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4,5,6,7}
Potential Trip Points : {}

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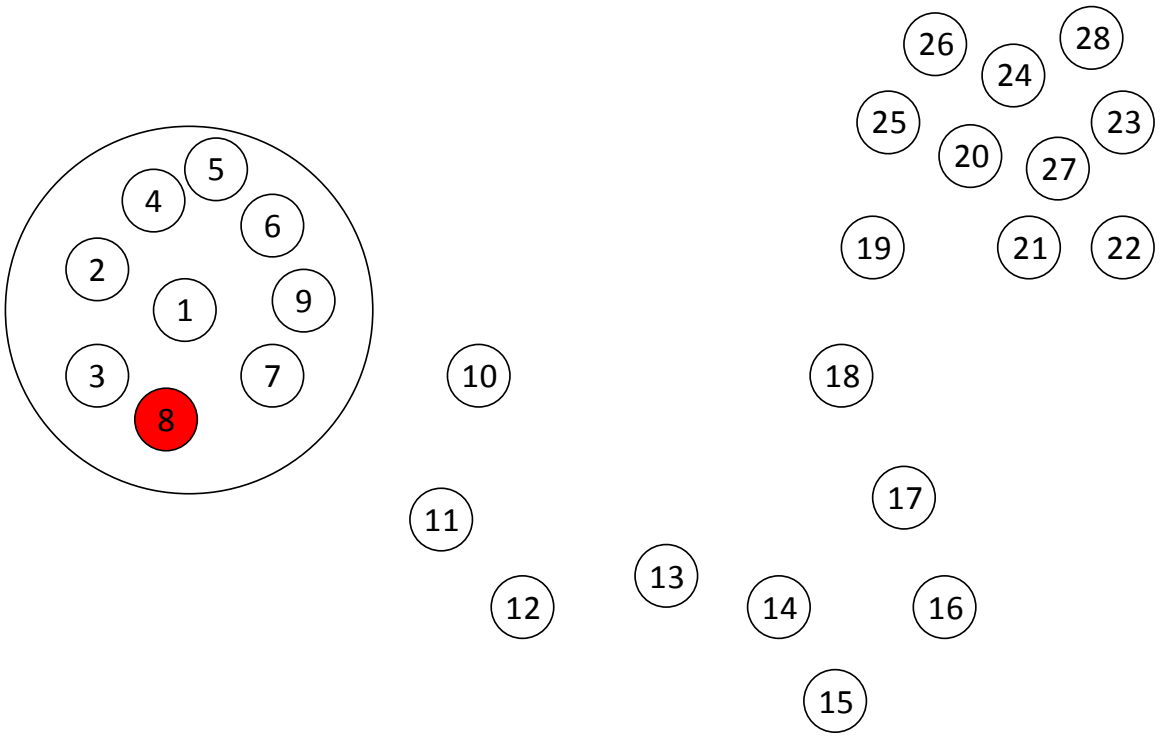
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4,5,6,7,8}
Potential Trip Points : {}

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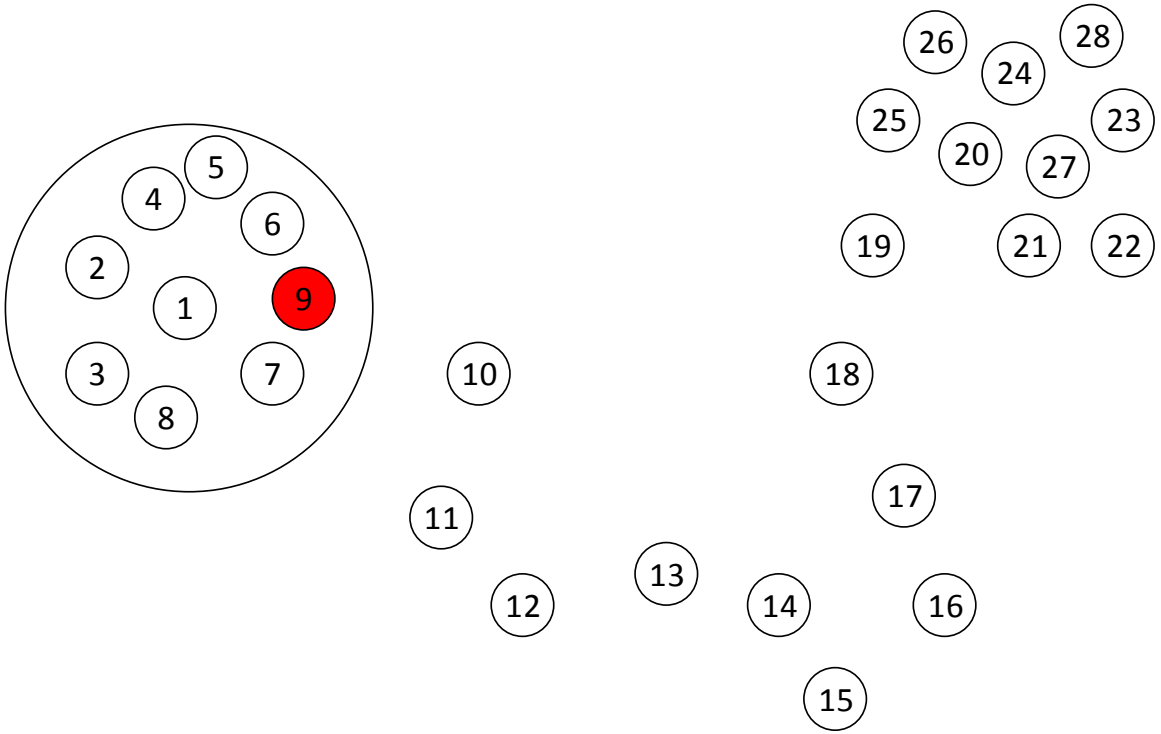
Example: Stop Detector



Cluster Center : {1}
Potential Stop Points : {1,2,3,4,5,6,7,8,9}
Potential Trip Points : {}

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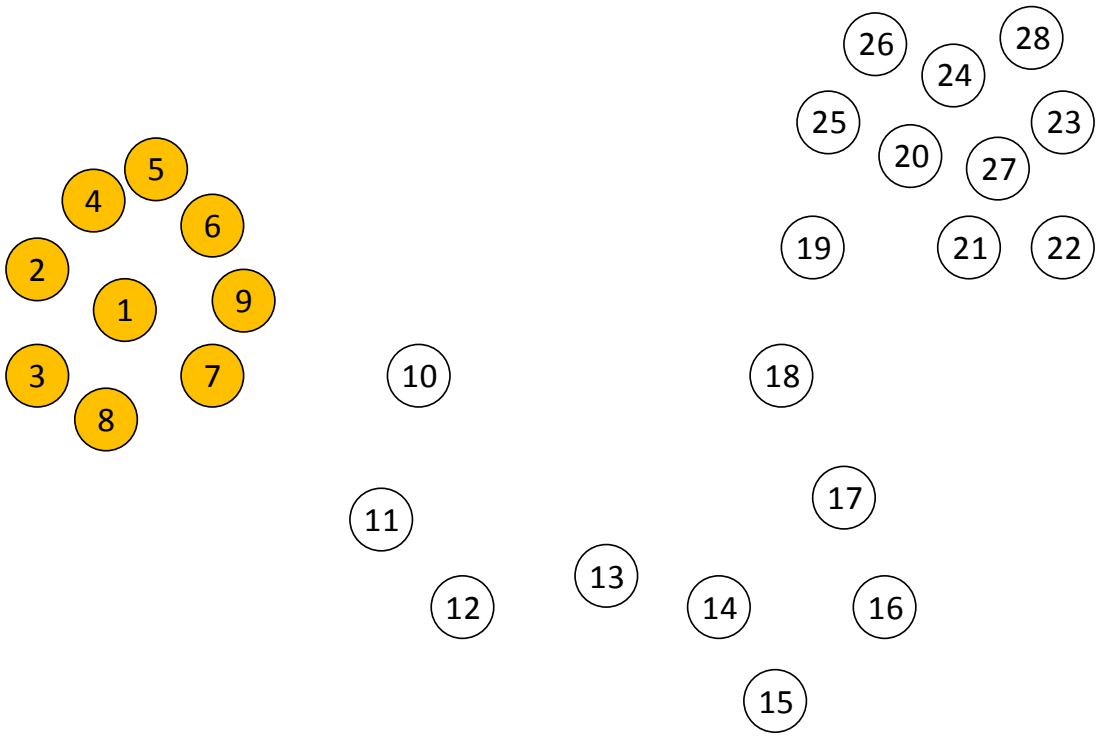
Example: Stop Detector

Stop is finished: 270 seconds in a radius of 100 meters



Cluster Center : {}
Potential Stop Points : {}
Potential Trip Points : {}

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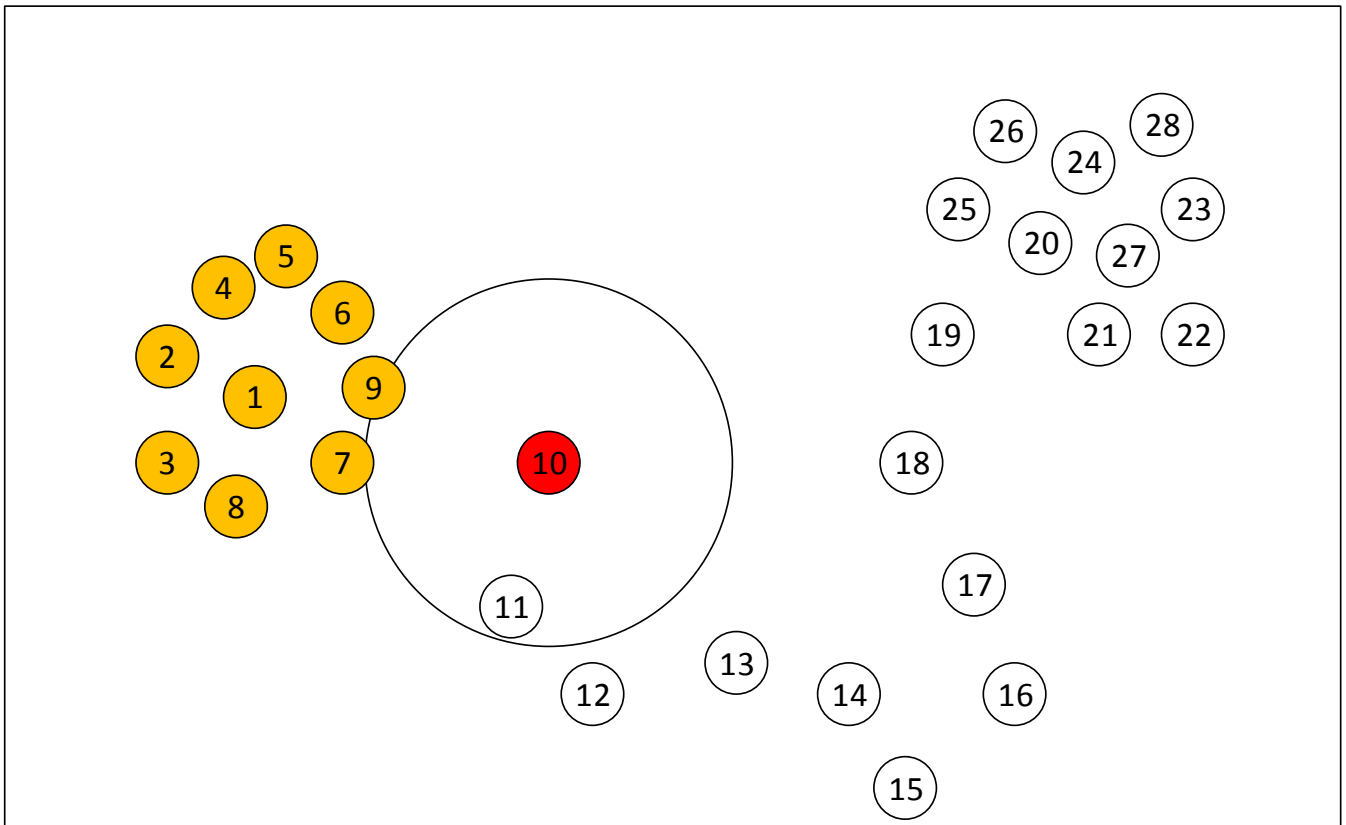
Example: Stop Detector



Cluster Center : {10}
Potential Stop Points : {10}
Potential Trip Points : {}

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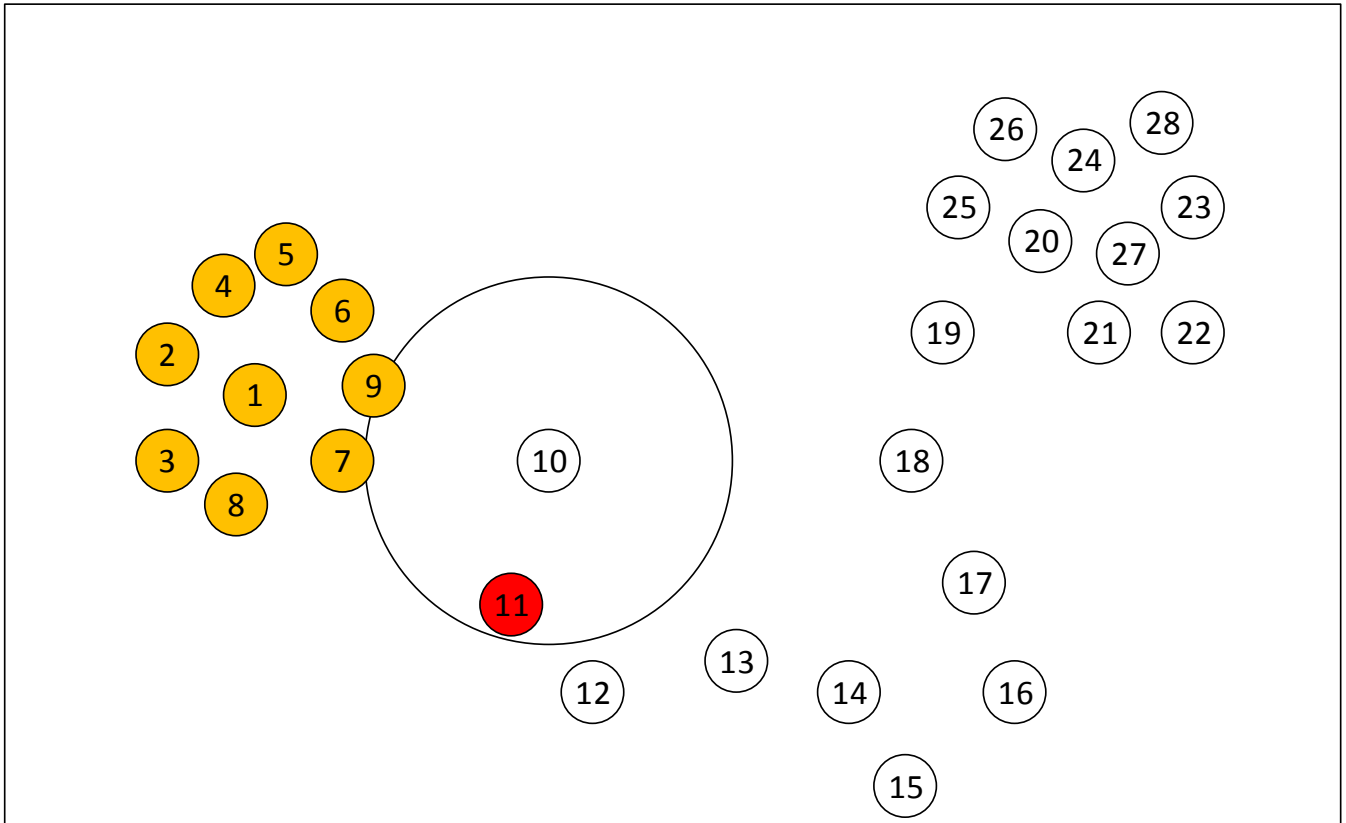
Example: Stop Detector



Cluster Center : {10}
Potential Stop Points : {10,11}
Potential Trip Points : {}

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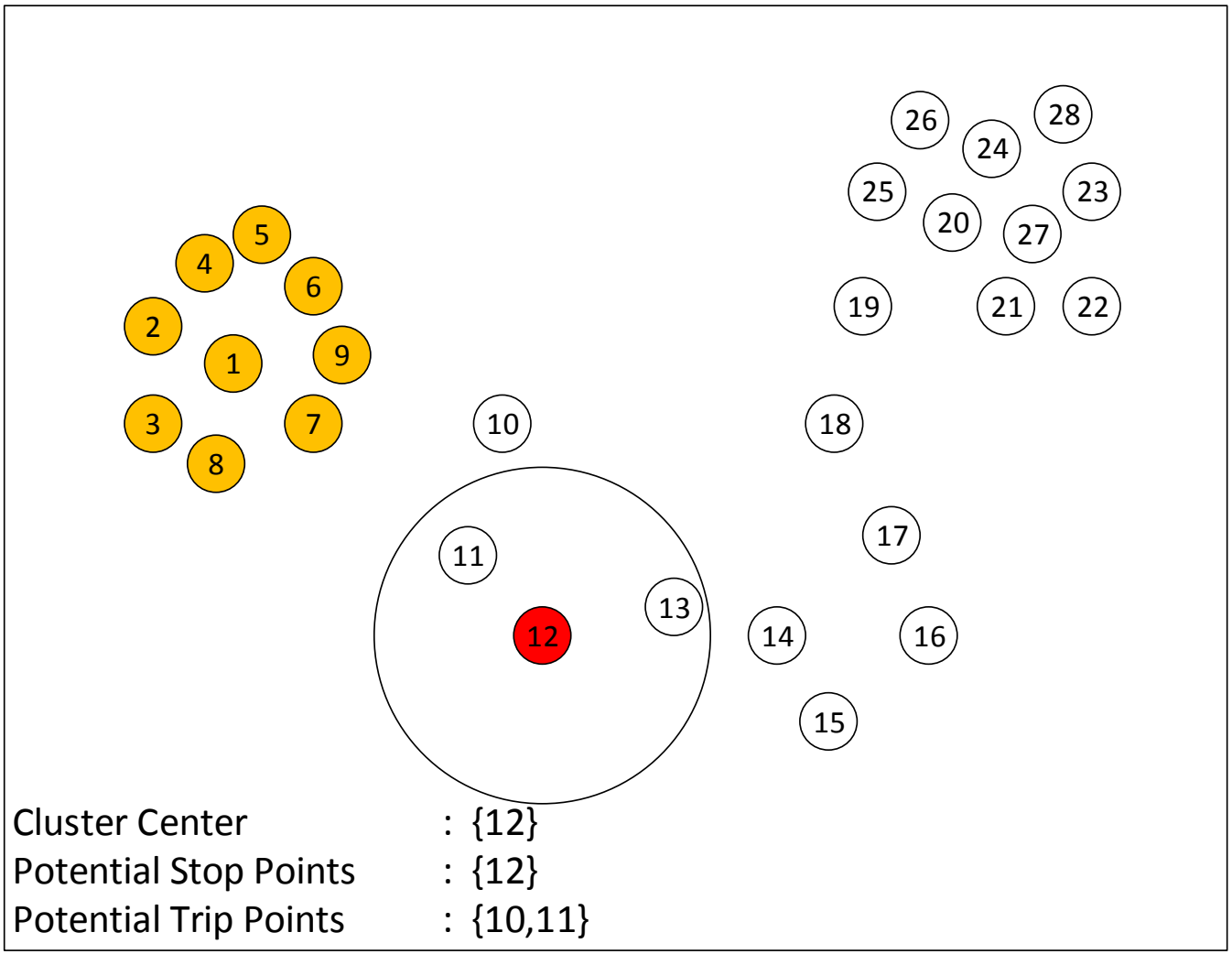
Example: Stop Detector



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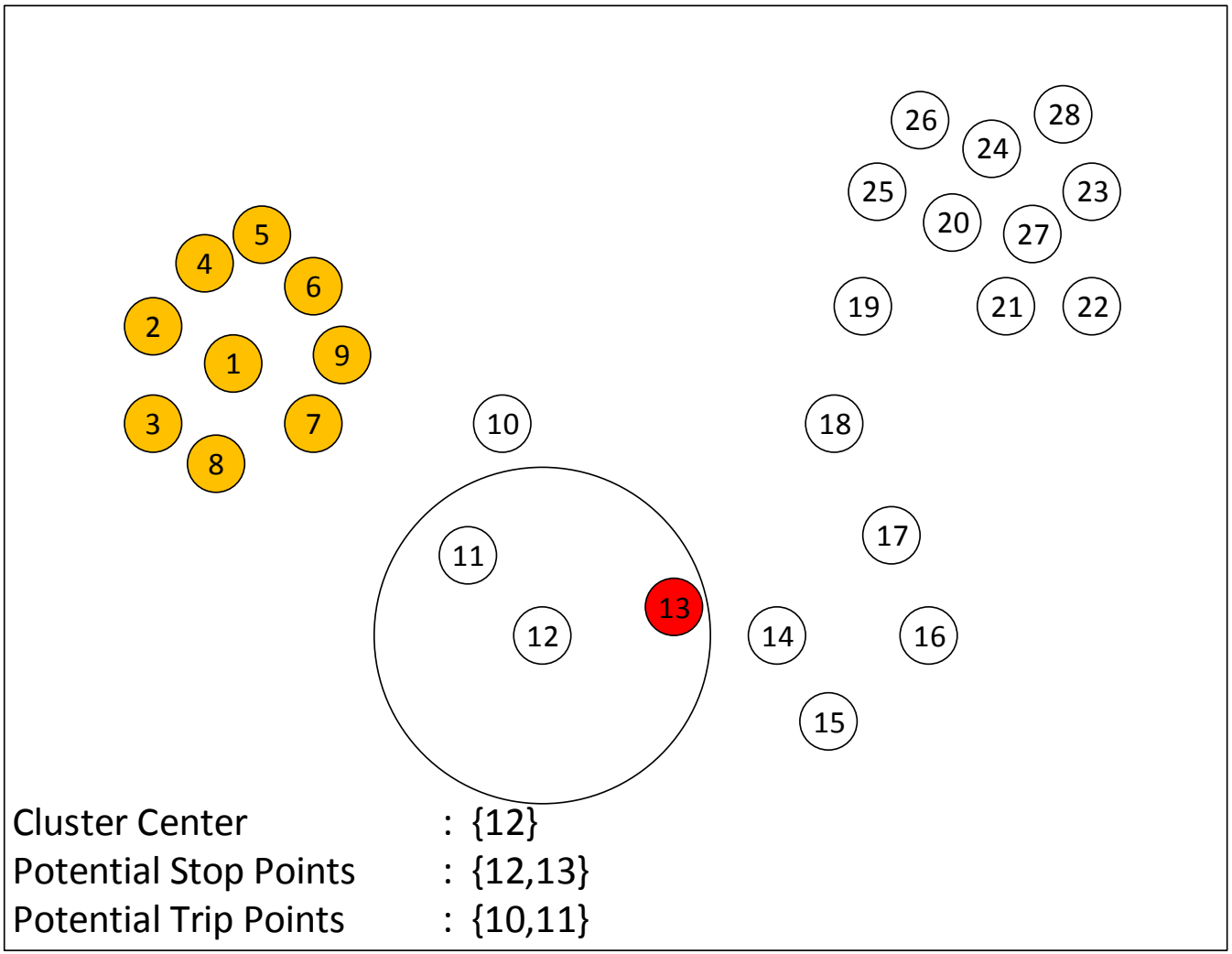
Example: Stop Detector



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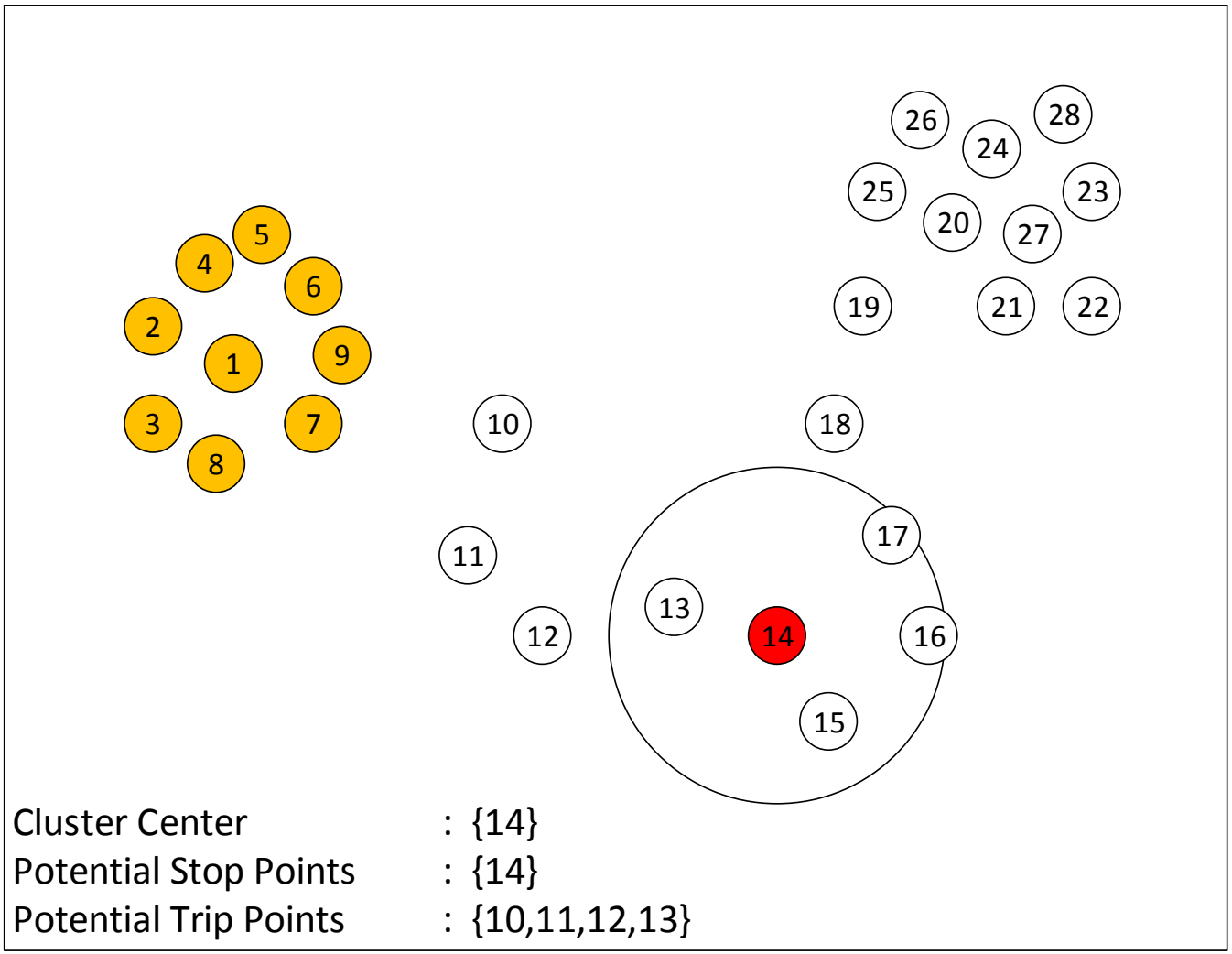
Example: Stop Detector



Cluster Center : {14}
Potential Stop Points : {14}
Potential Trip Points : {10,11,12,13}

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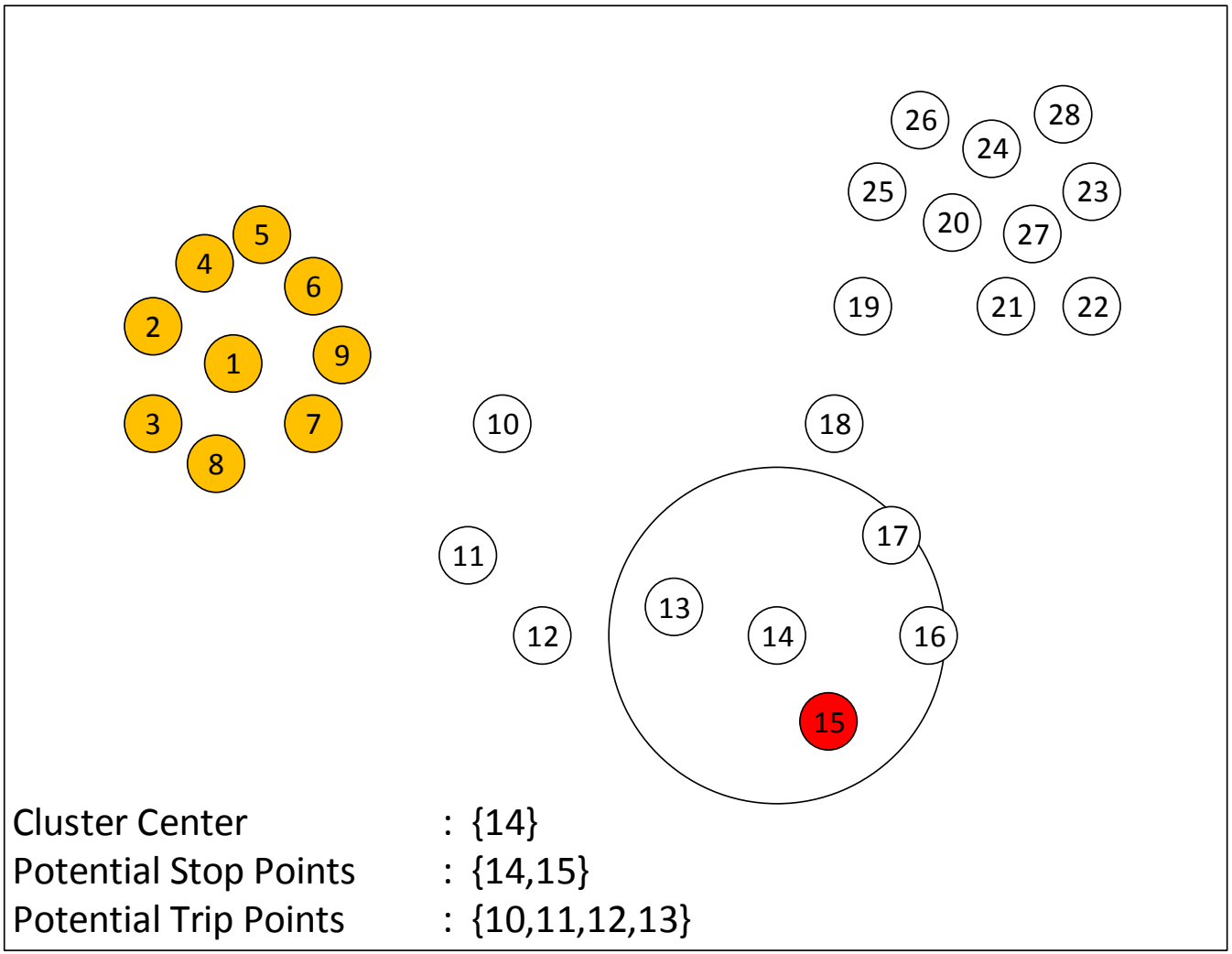
Example: Stop Detector



Cluster Center : {14}
Potential Stop Points : {14,15}
Potential Trip Points : {10,11,12,13}

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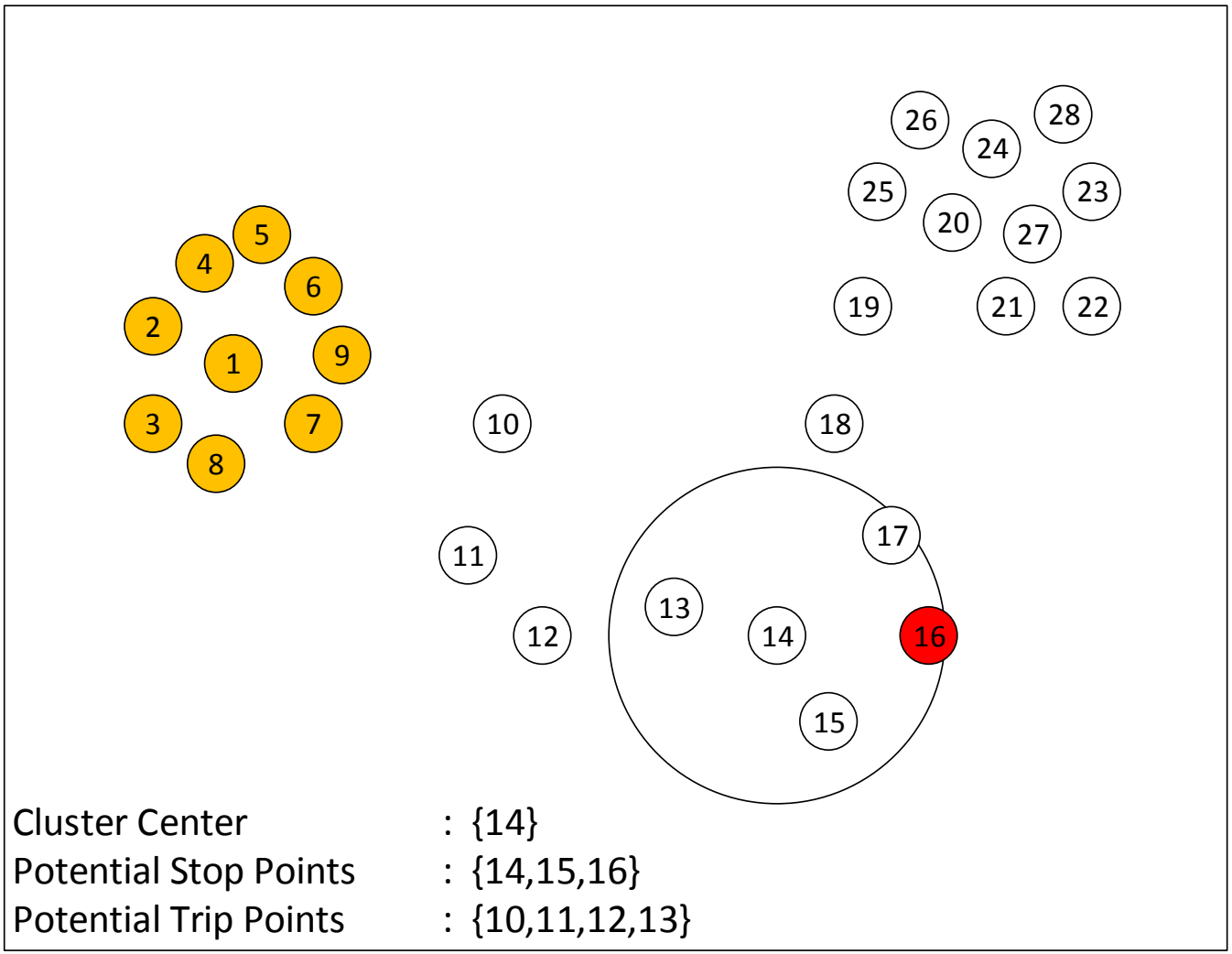
Example: Stop Detector



Cluster Center : {14}
Potential Stop Points : {14,15,16}
Potential Trip Points : {10,11,12,13}

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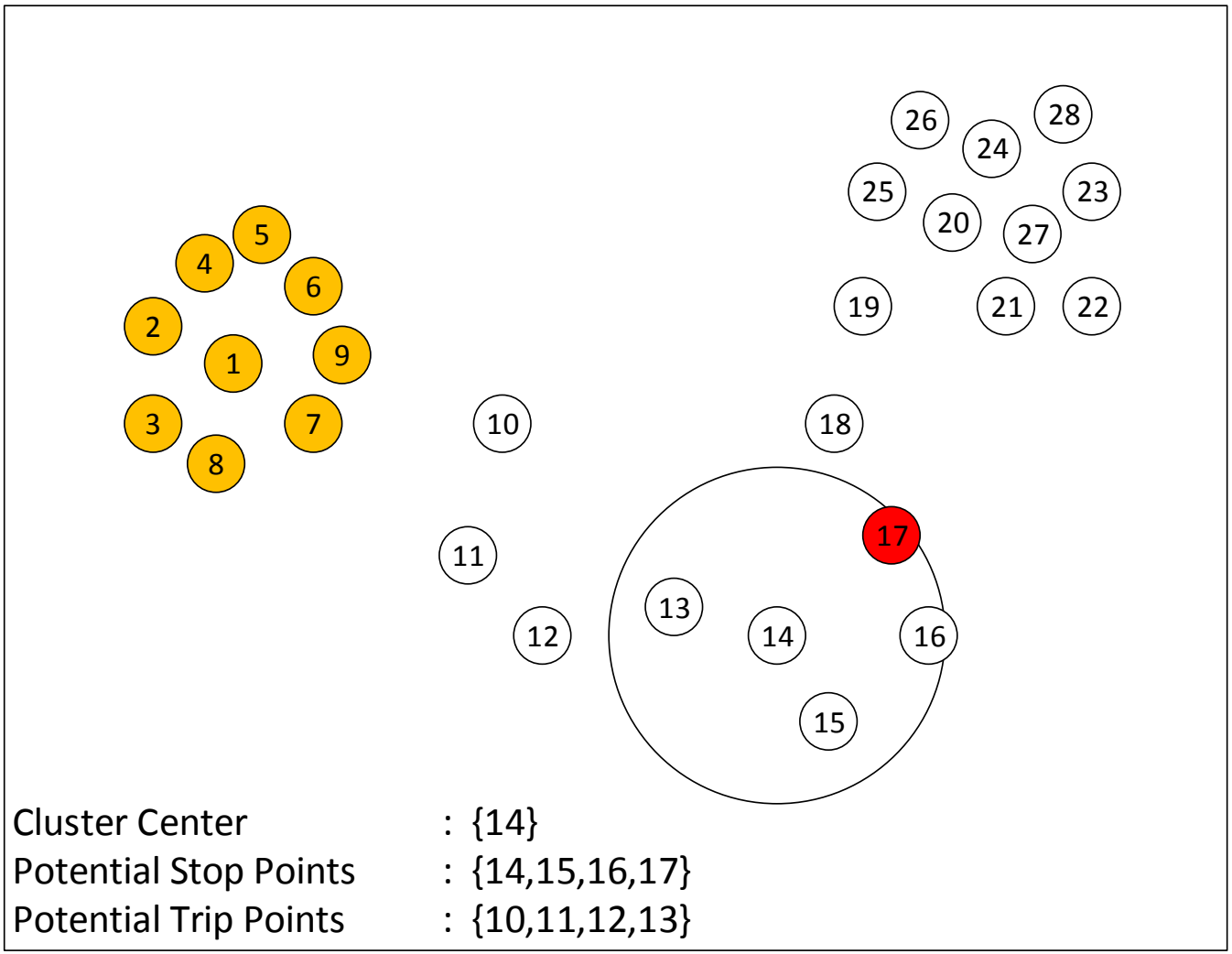
Example: Stop Detector



Cluster Center : {14}
Potential Stop Points : {14,15,16,17}
Potential Trip Points : {10,11,12,13}

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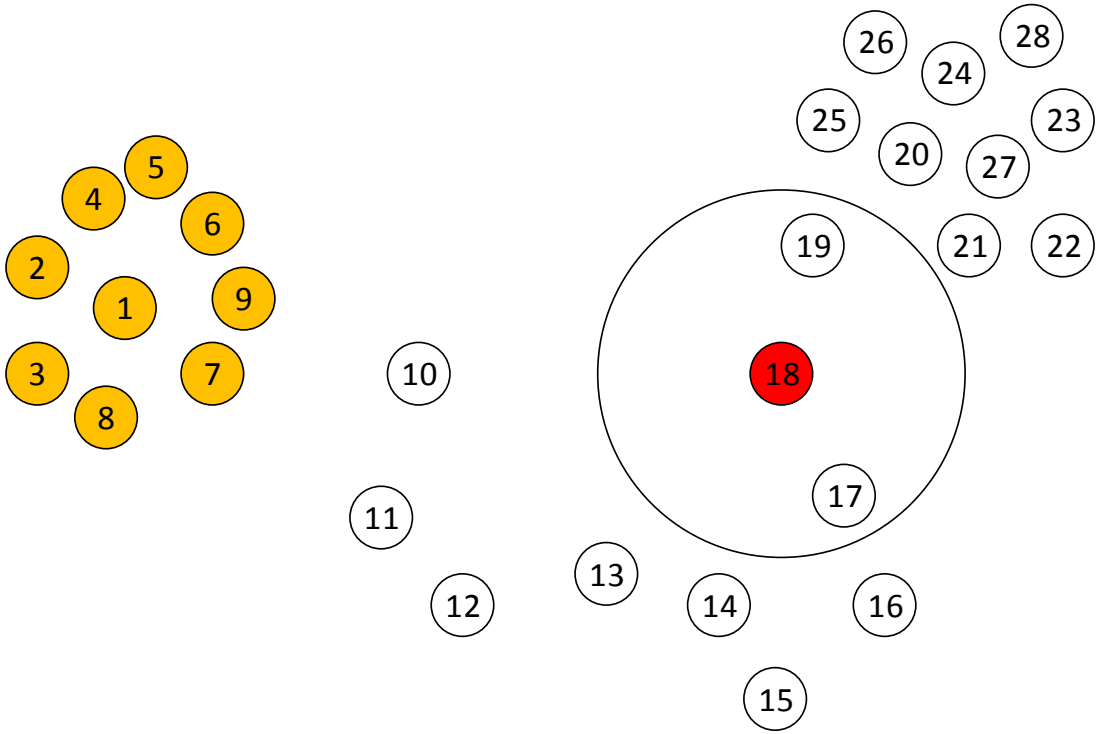
Example: Stop Detector



Cluster Center : {18}
Potential Stop Points : {18}
Potential Trip Points : {10,11,12,13,14,15,16,17}

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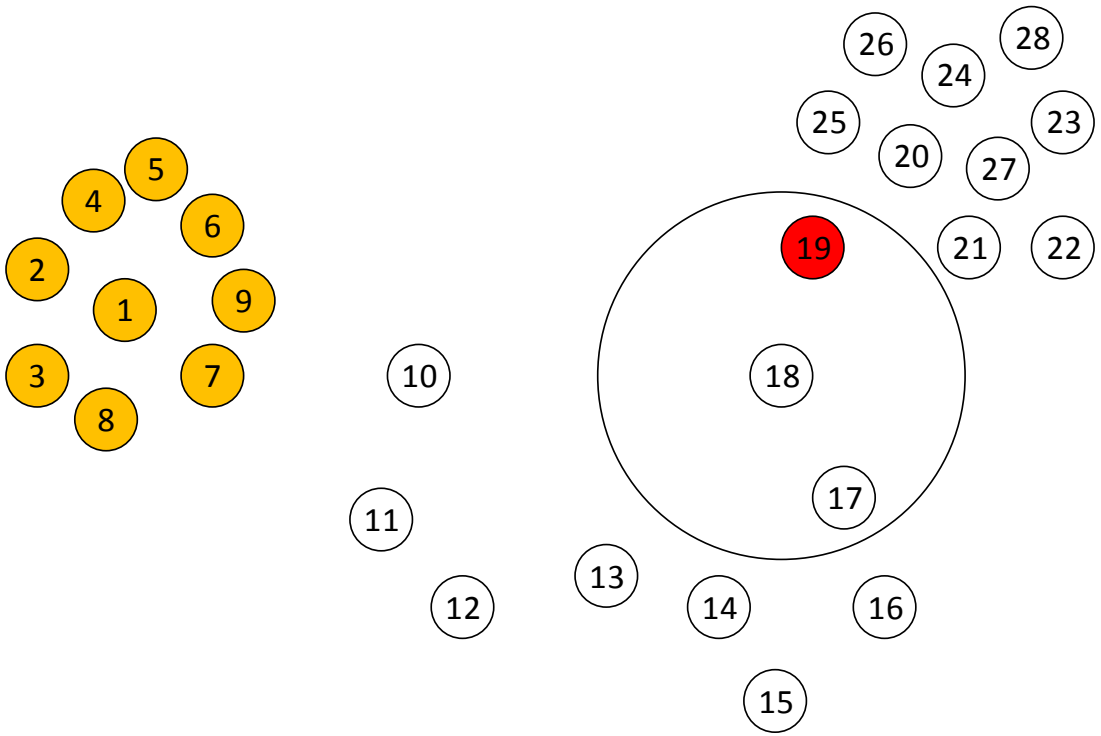
Example: Stop Detector



Cluster Center : {18}
Potential Stop Points : {18,19}
Potential Trip Points : {10,11,12,13,14,15,16,17}

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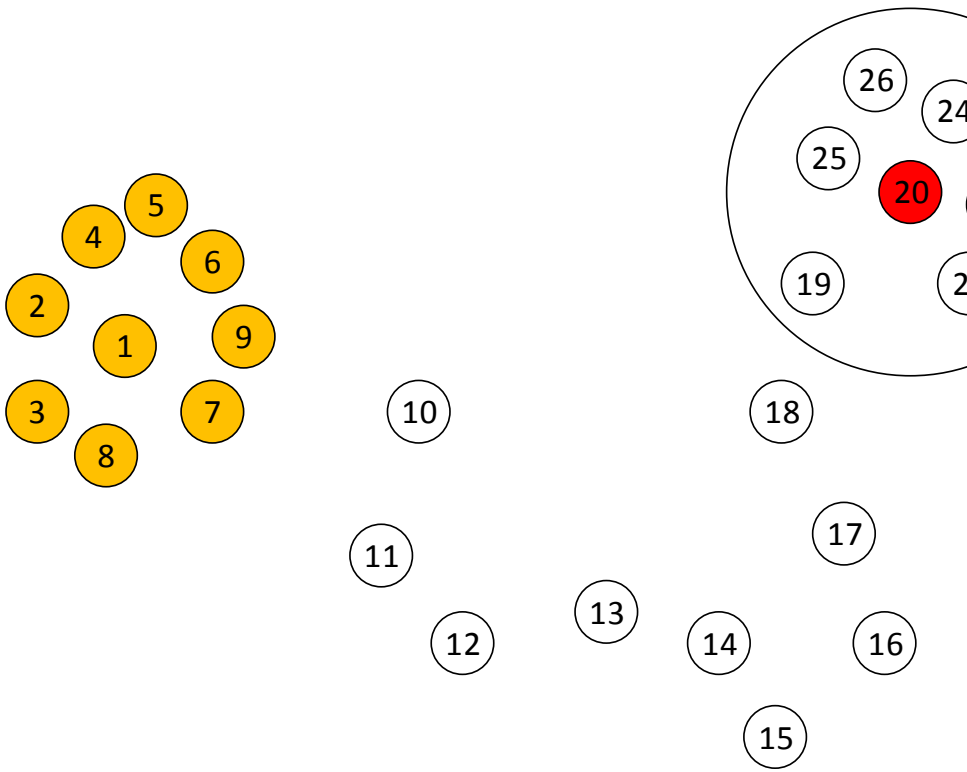
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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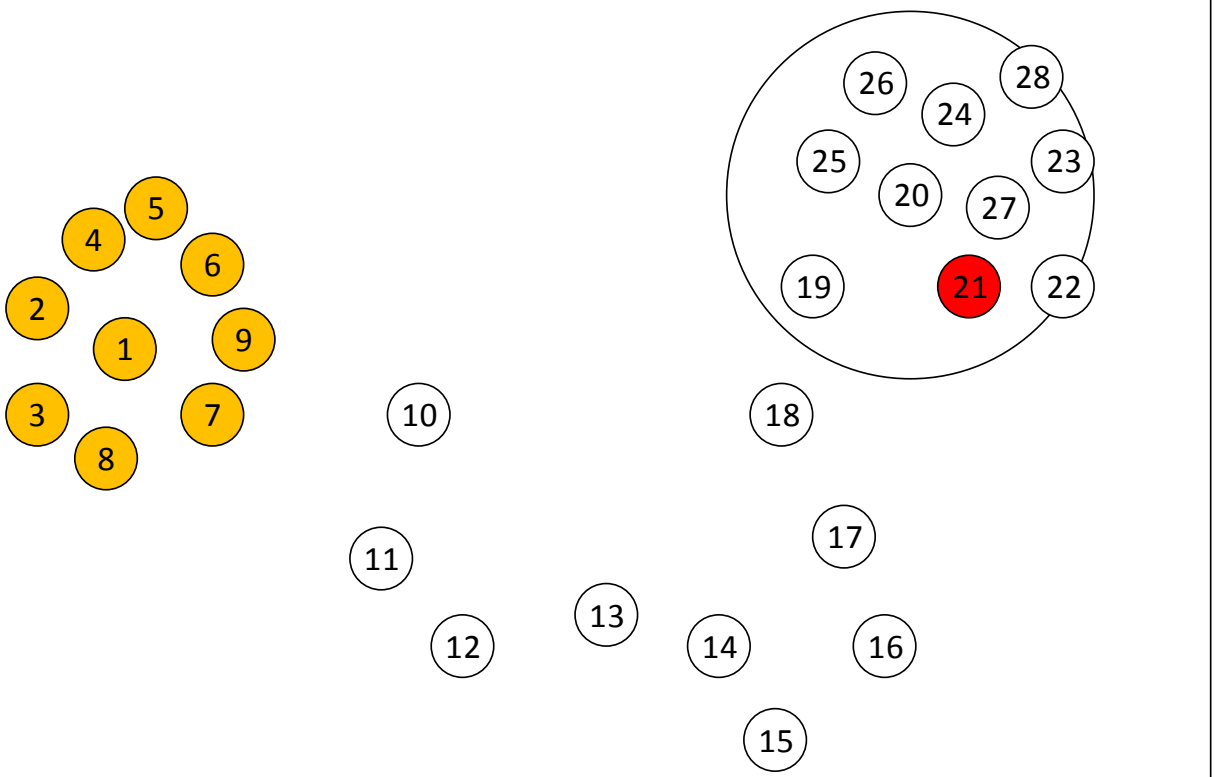
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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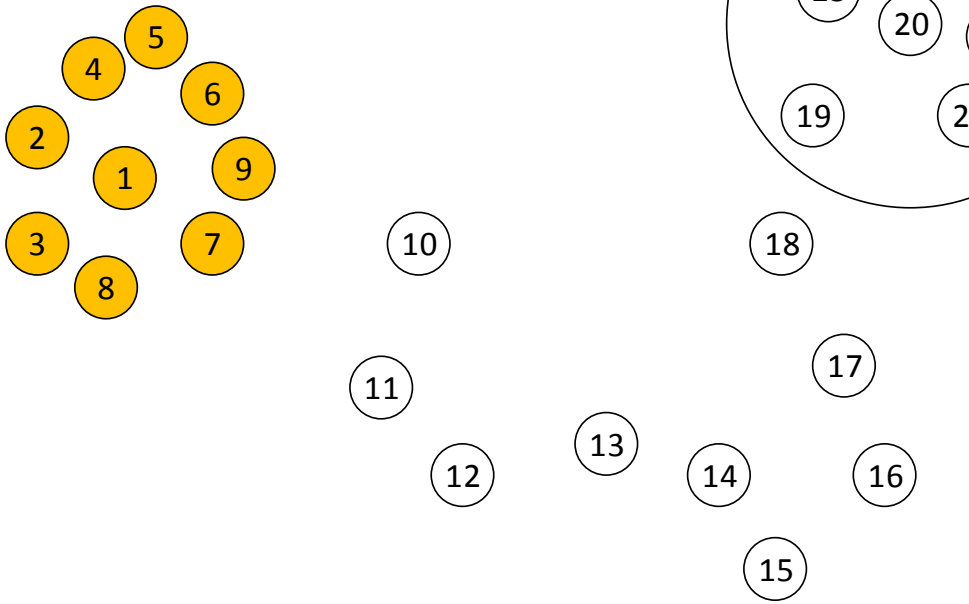
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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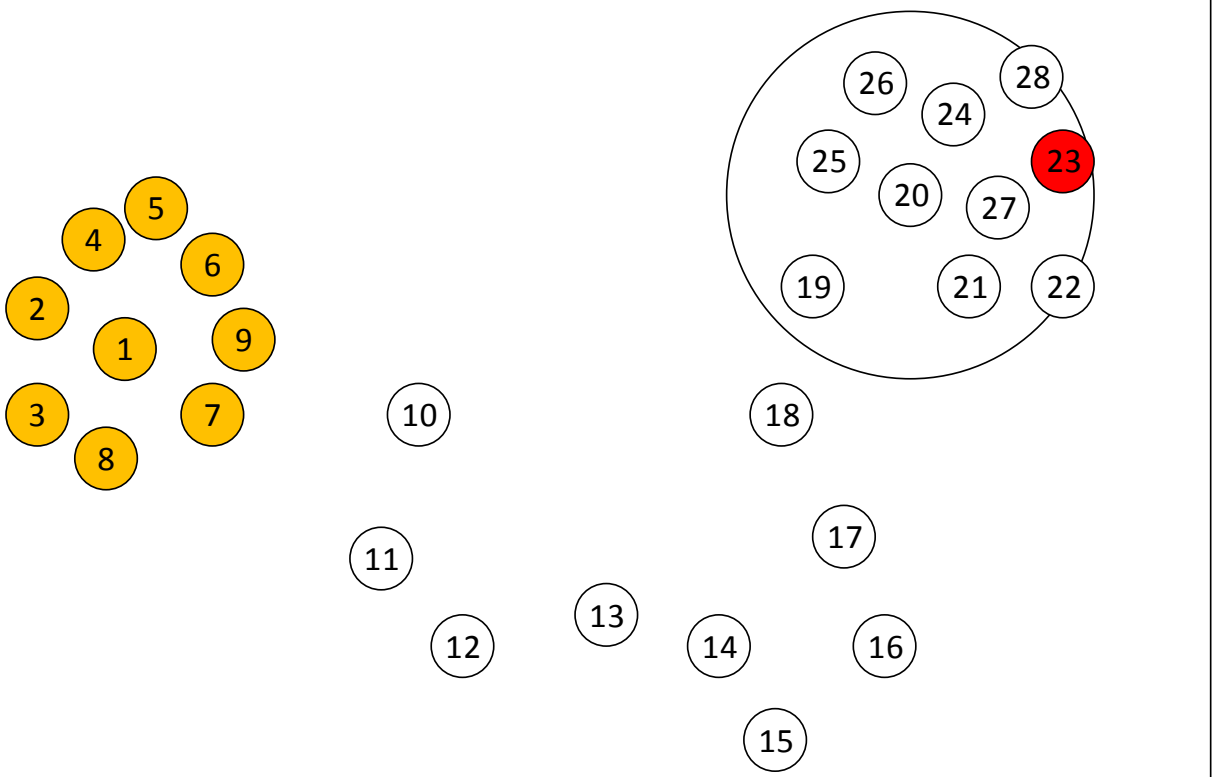
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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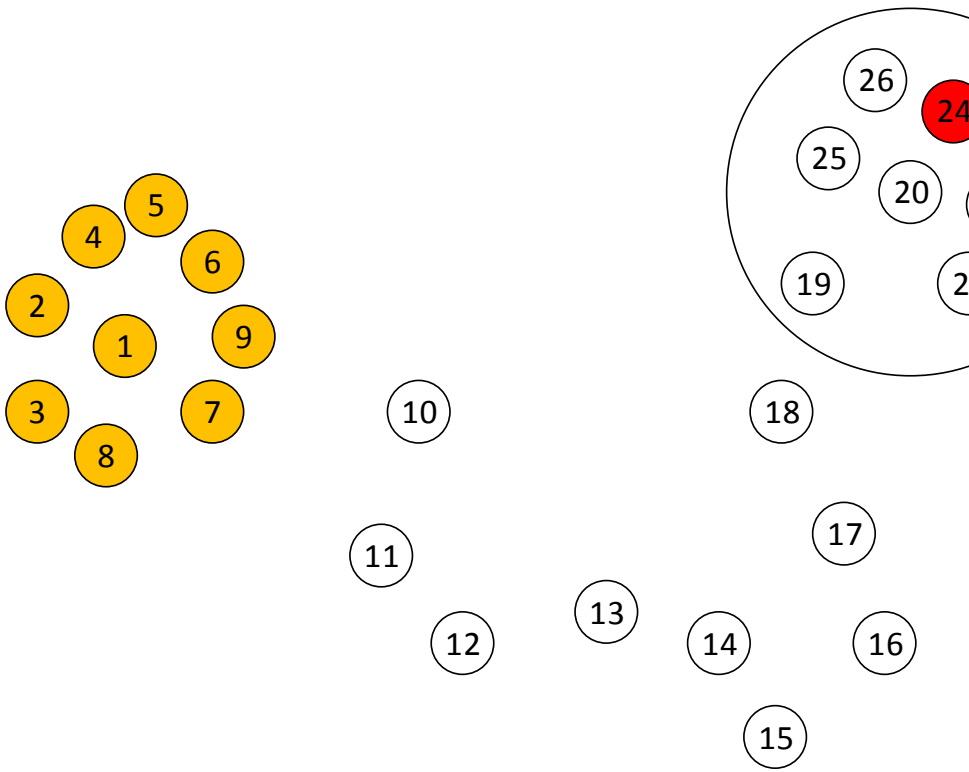
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23,24}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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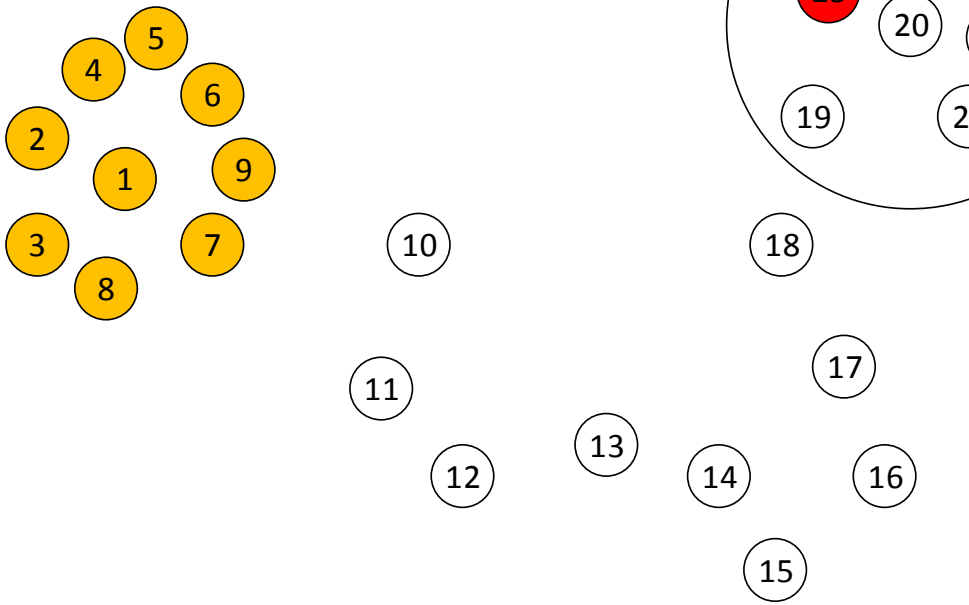
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23,24,25}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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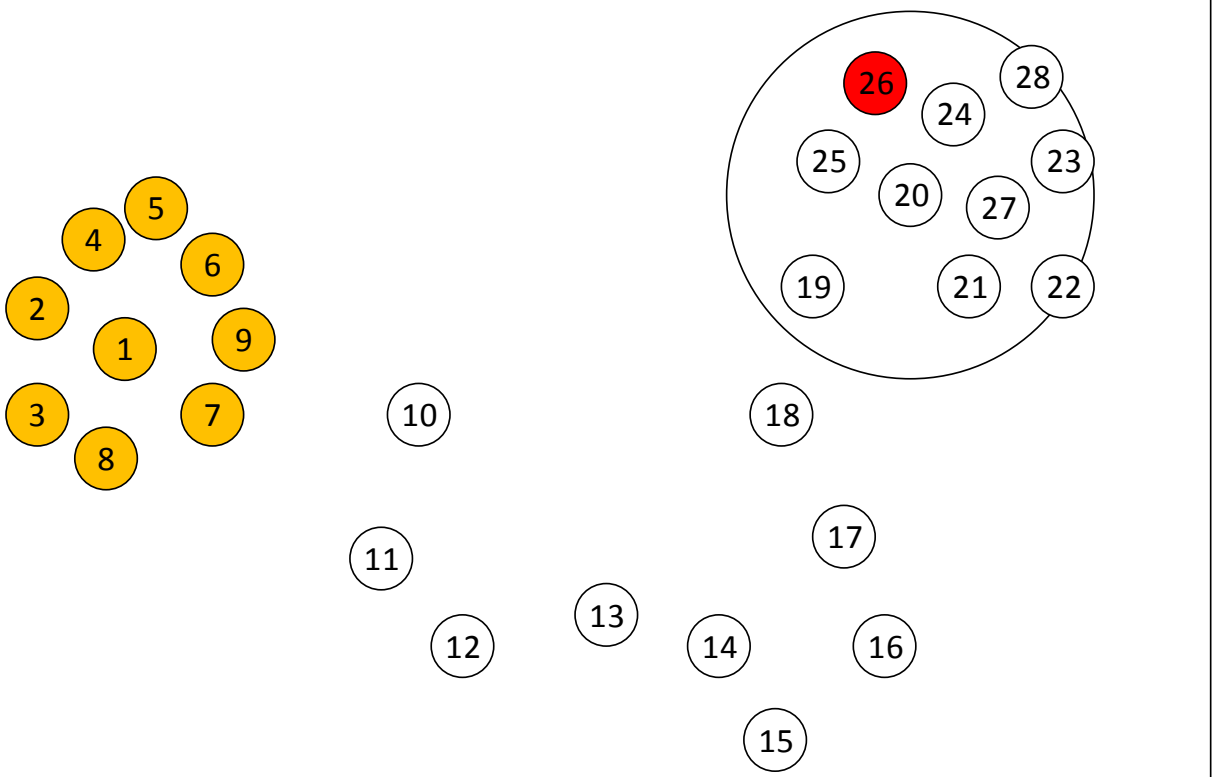
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23,24,25,26}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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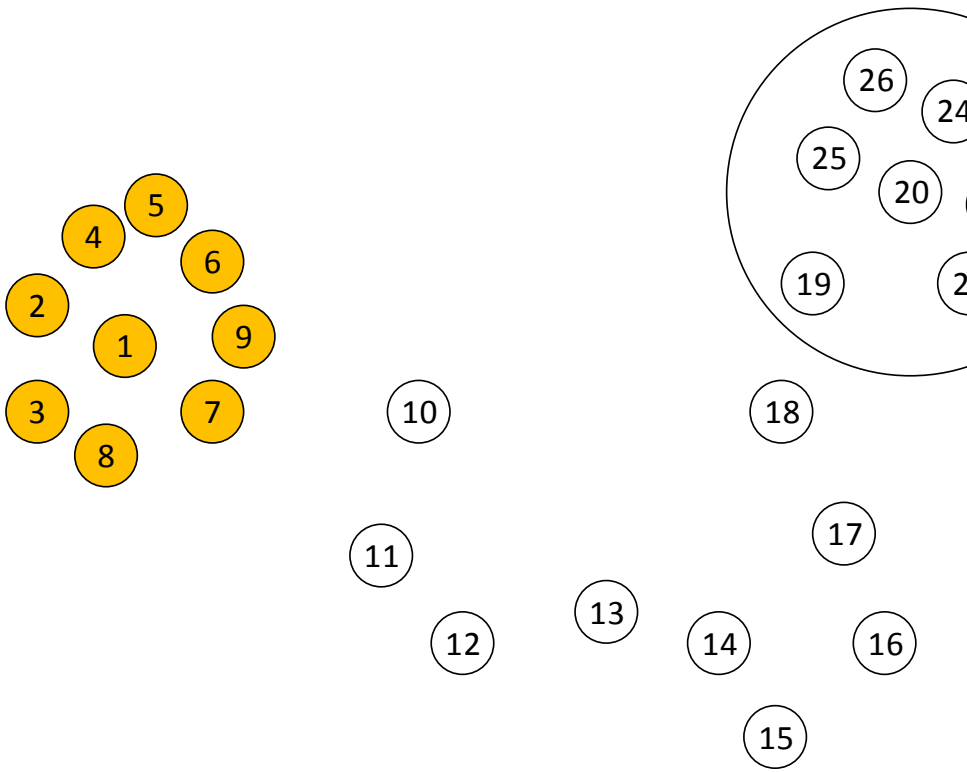
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23,24,25,26,27}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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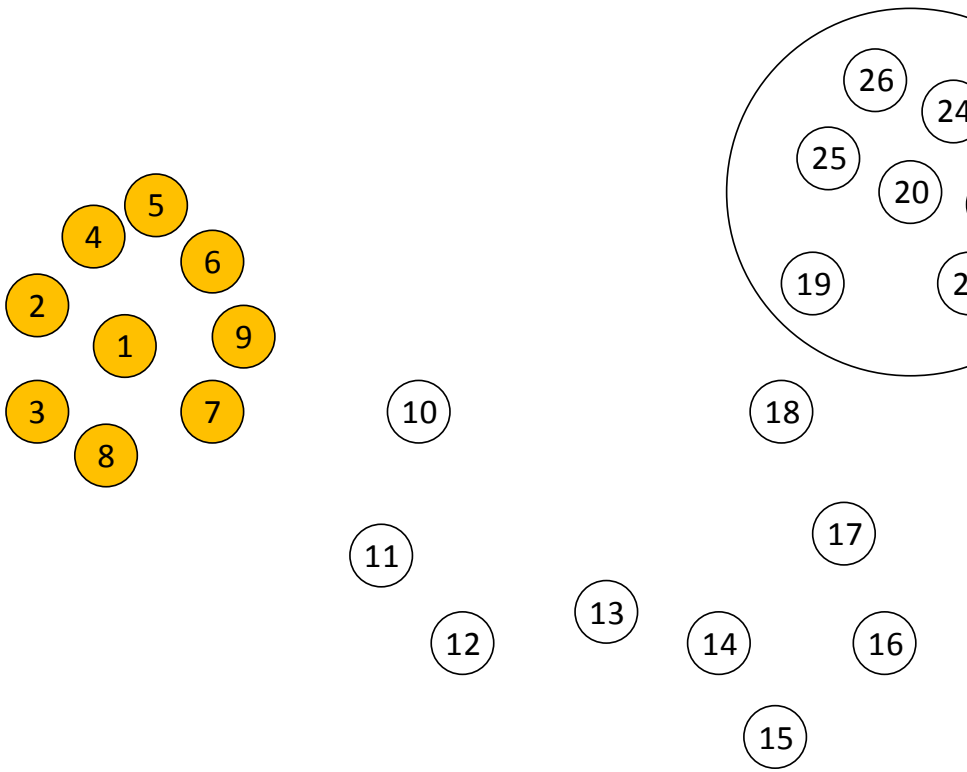
Example: Stop Detector



Cluster Center : {20}
Potential Stop Points : {20,21,22,23,24,25,26,27,28}
Potential Trip Points : {10,11,12,13,14,15,16,17,18,19}

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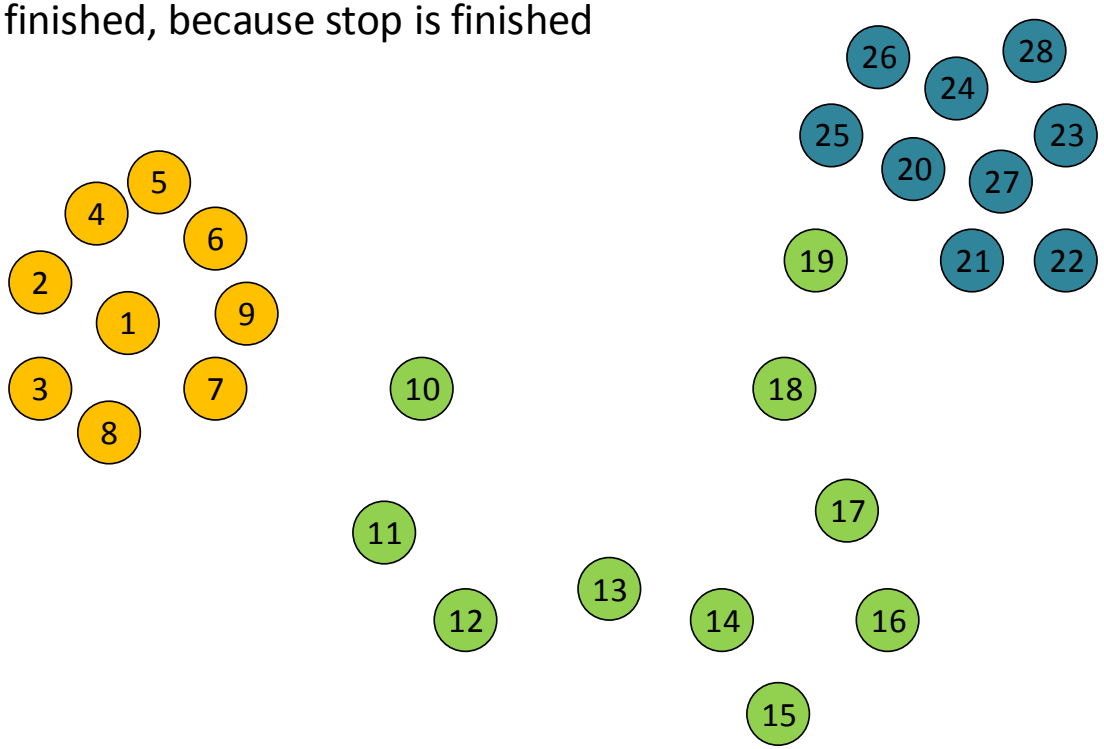
Example: Stop Detector

Stop is finished: 270 seconds in a radius of 100 meters
Trip is finished, because stop is finished



Cluster Center : {}
Potential Stop Points : {}
Potential Trip Points : {}

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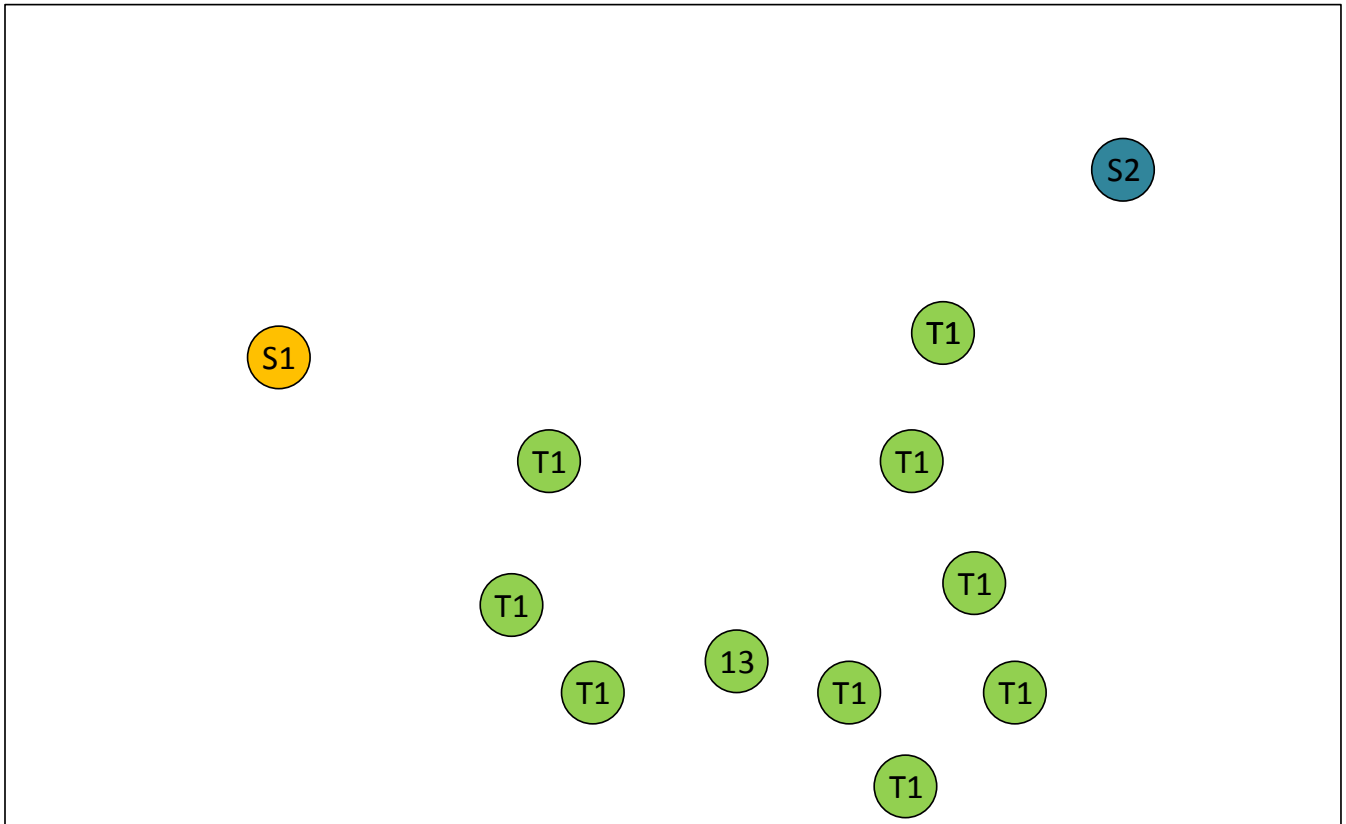
Example: Stop Detector



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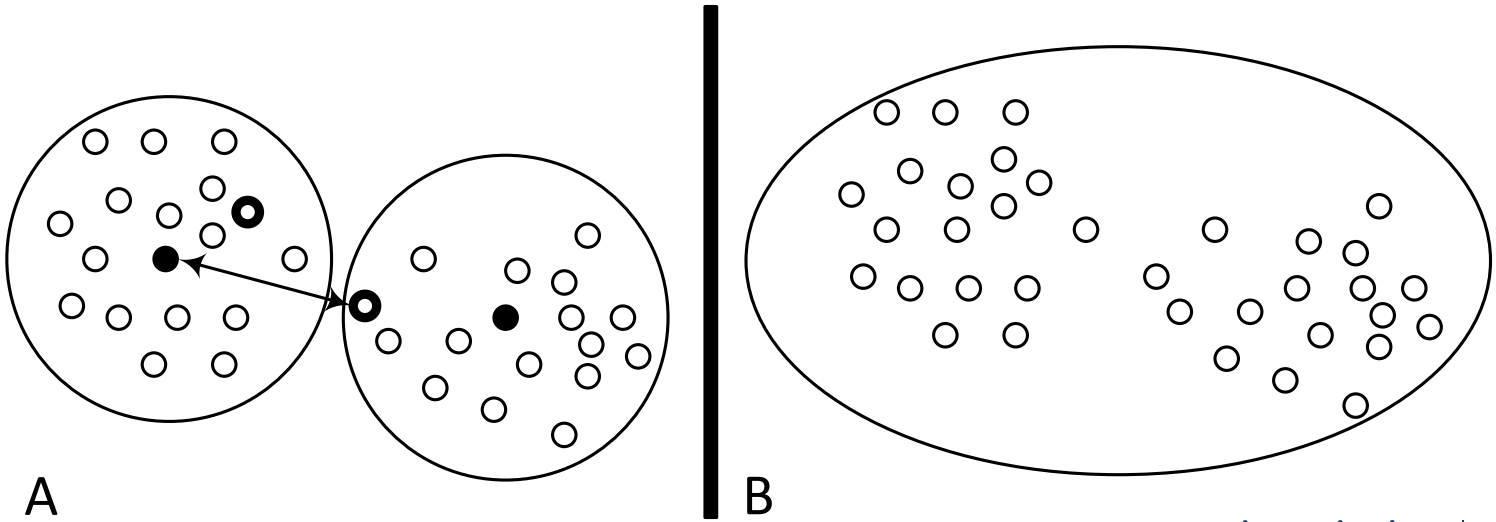
Extra Checks: Merging of stops

1. When two *stop clusters* are close together in both
   - time and
   - space



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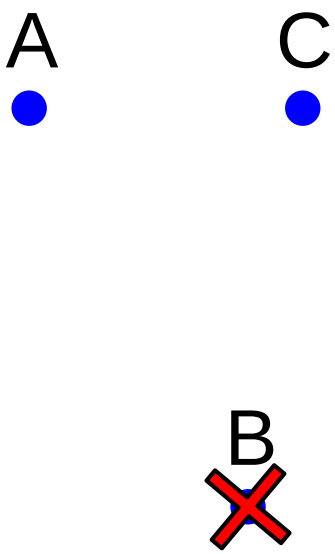
Extra Checks: Validity of a stop

1. $\forall A, B \in Stops | B\ DirectSuccessorOf\ A : Speed(A,B) > threshold$: delete stop B



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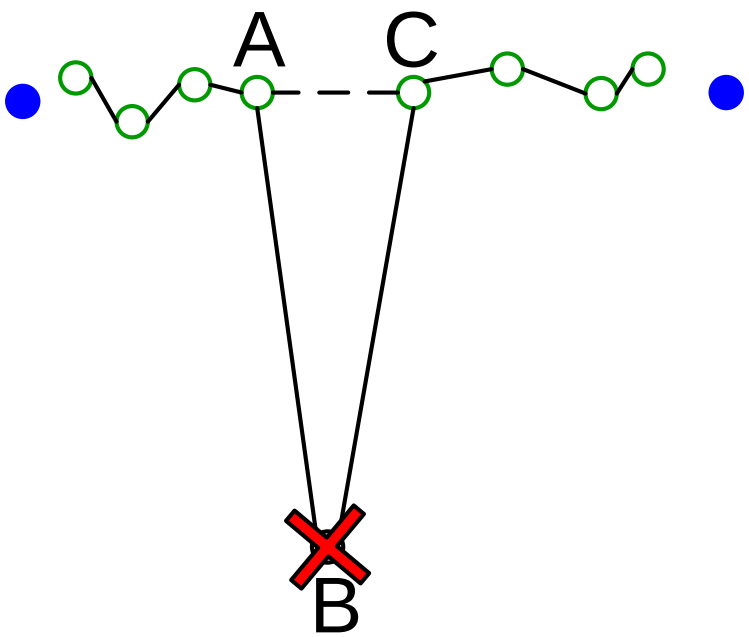
Extra Checks: Validity of a trip

1. $\forall A, B \in Trips | B\ DirectSuccessorOf\ A : Speed(A,B) > threshold$: delete trip point B



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Overview

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Data: Input & Threshold Parameters

1. Input
   - Person traces of a certain amount of persons
   - Manually aligned data
   - Interactively corrected by our researchers
   - = Base truth
2. Threshold Parameters
   - Stop Duration threshold[sec] = {60, 90, 120, 150, 180, 210, 240, 300, 360, 420}
   - Stop Distance threshold[m] = {25, 50, 75, 100, 125, 150, 200, 250, 300, 400}

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Techniques: Computations

1. Find the combination of Stop Duration threshold and Stop distance threshold that gives the best results
2. Quality indicators:
   - Averages
     - Trip speed
     - Trip duration
     - Trip distance
   - Number of trips
   - Temporal trip matching indicator in [0,1]: measure for overlap between reported and detected trip intervals
     - $Temporal\_Indicator = \frac{sum(all\ period\ intersections)}{sum(all\ period\ unions)}$
     - 0.0 : no overlap
     - 1.0 : exact overlap
3. Ranked Squared Error

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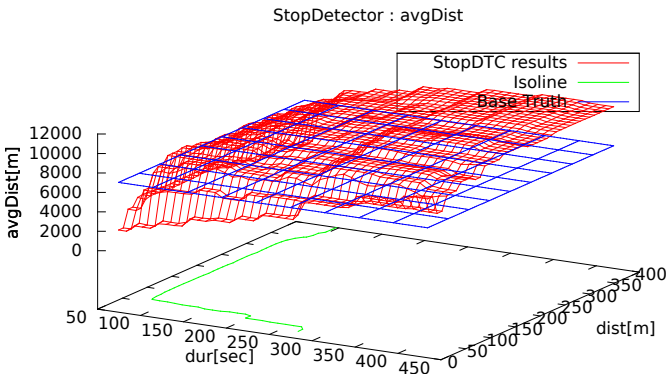
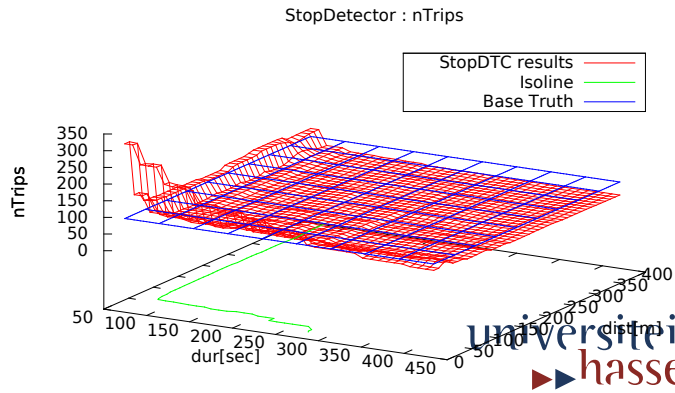
Techniques: Plots

1. (Stop distance, stop duration) combination [nTrip, avgDistance, avgSpeed,avgDuration]
2. Red plane: result of the stop detector
3. Blue plane: base truth
4. Green line: isoline → intersection between base truth and result of stop detector
5. Nice indicator, but not accurate





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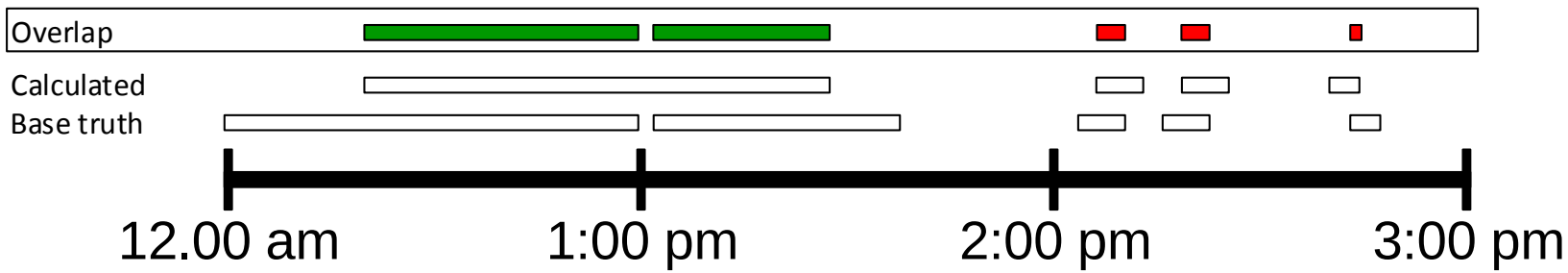
Techniques: Temporal Trip Indicator

1. Small trips give misleading results
2. Sensitive to overlap measures



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Techniques: Ranked Squared Error

1. Used to decide the best combination of *Stop Duration Threshold* and *Stop distance Threshold*
2. Calculate squared error for
   - number of trips and
   - temporal indicator
3. Calculation of squared error:
   - Deviation between detected and base truth results
   - Deviations are squared and summed (for every threshold parameter combination per person)
4. Results in two lists (for numberOfTrips and for temporalIndicator)
   - Ranks per combination are summed
   - Combination having the lowest rank is the winner

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Results: Ranked Squared Error

1. Takes into account the most important indicators (for this research)
   - Amount of trips
   - Temporal indicator
2. Final result:
   - Stop Duration of 180 seconds (3 minutes)
   - Stop Distance of 100 meters

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Remarks: Variability in results

1. Observed variability in the results
2. Due to usage of person traces
   - Slow movement
   - Limited trip lengths
   - Entering buildings
3. This "optimal result" does not give the best result for every person
   - Some problems when persons perform a lot of short trips

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Overview

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Conclusion

1. Stop Detector
2. Find best values for the combination of stop duration and stop distance
3. Hard to find an optimal values for the thresholds due to the variability of the results

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Questions?