Spatio-Temporal Situation Recognition in Service Fields

- Validation by Discrete-Event Simulation -

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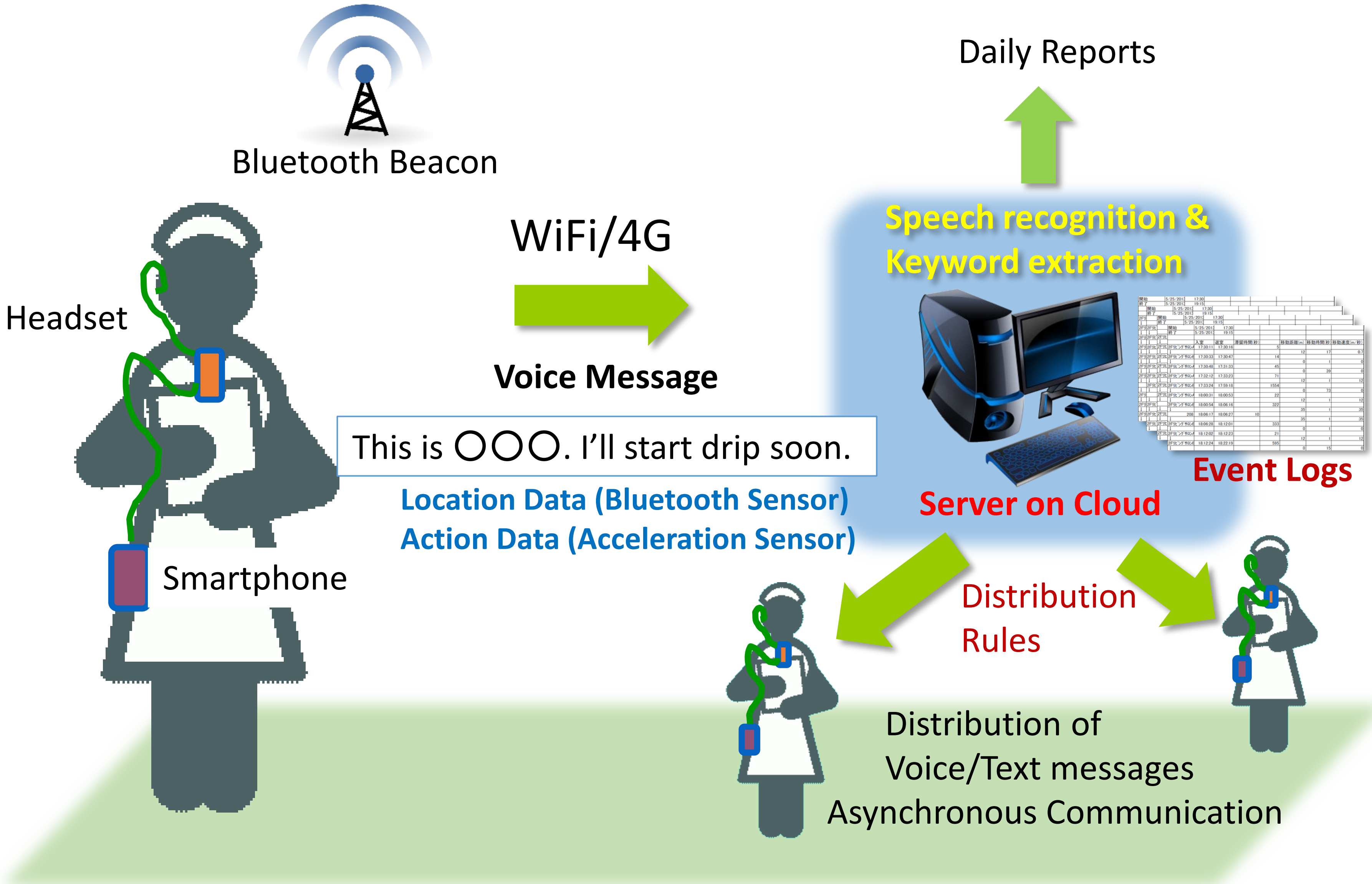
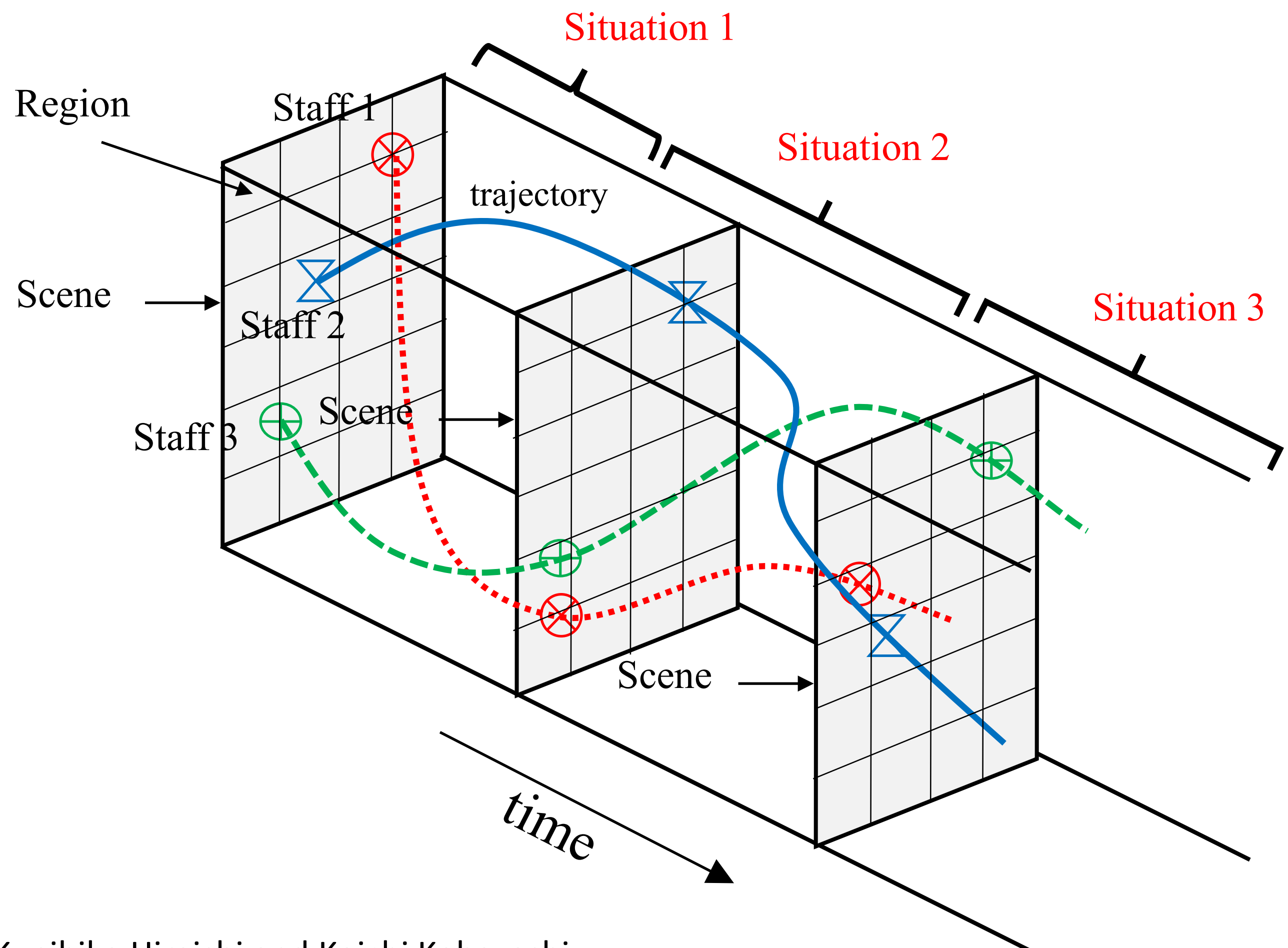
Smart Voice Messaging System



Spatio-Temporal Situation Recognition



Kaoru Sato, Kunihiko Hiraishi and Koichi Kobayashi:
Spatio-Temporal Situation Recognition for Groups in Caregiving Services,
IEEE CogSIMA2016, pp.78-82 (2016/3/21-25, San Diego, USA)

Spatio-Temporal Situation Recognition

- Phase I: Recognition of Scenes
  1. From the event log, we make *place vectors*. Place vectors indicates how persons are arranged in the space.

     1 2 3 4 5 6 7 8 9 10

     [0, 0.5, 0, 3, 2.5, 0, 0, 0, 0, 0]

     There are 10 regions. Three persons are in region 4, two persons are in region 5, and one person is moving from region 2 to region 5 (0.5 is added to region 2 and region 5).

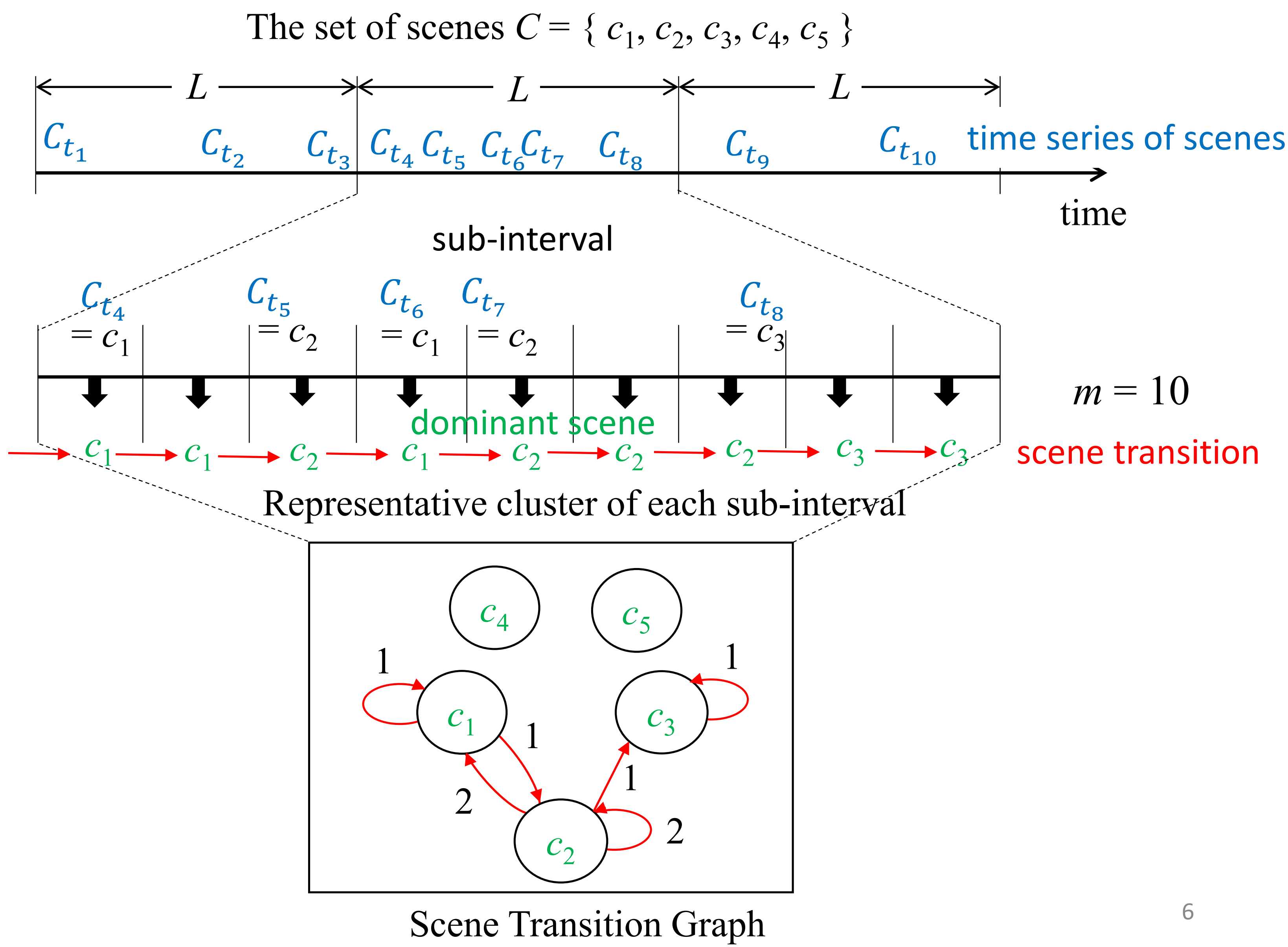
  2. A clustering algorithm is applied to the set of place vectors and we obtain a set of clusters $C = \{ c_1, \ldots, c_n \}$. Each c_i is called *a scene*.

Spatio-Temporal Situation Recognition

- Phase II: Recognition of Scene Transition
  1. A time series of place vectors $v_{t_1}, v_{t_2}, \ldots \; (t_1 < t_2 < \ldots)$ is transformed into a time series of scenes $C_{t_1}, C_{t_2}, \ldots$.
  2. Time axis is divided into intervals with length L.
  3. Each interval is further divided into m sub-intervals.
  4. Decide a dominant scene for each subinterval.
  5. Make *a scene transition graph* for each interval.
  6. Clustering of the set of scene transition graphs. Each cluster is called *a situation*.

Situation = How scenes change with time

Spatio-Temporal Situation Recognition



Aim

- The proposed method is applied to a small number of real data obtained in a nursing home.
- In this paper, we validate the method by artificial logs generated by discrete event simulation.
  - to find cases that the proposed method does not work well
  - to find idea toward improvement

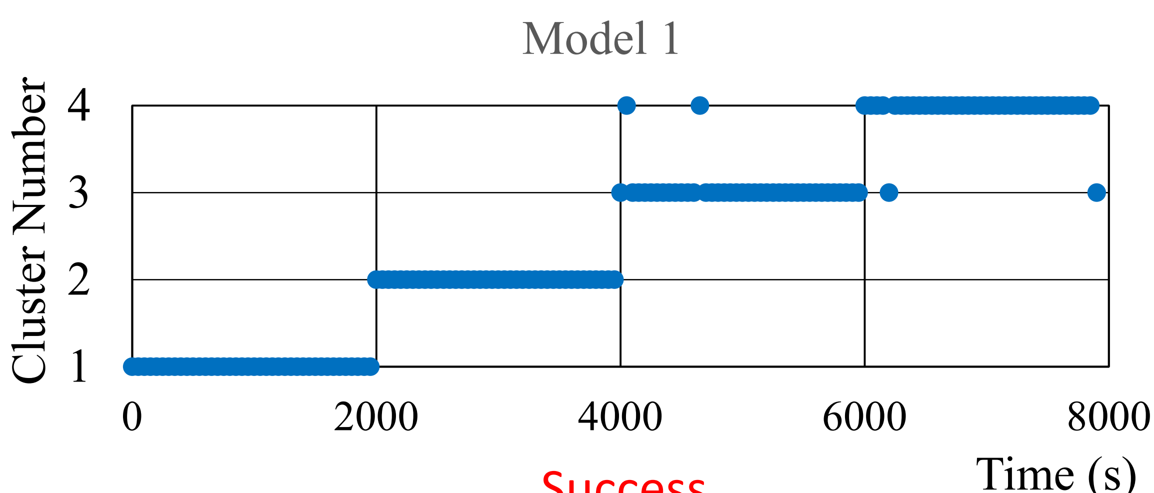
Simple Model 1

- There are five rooms 1 - 5 and three persons P_1, P_2, P_3.

Model 1

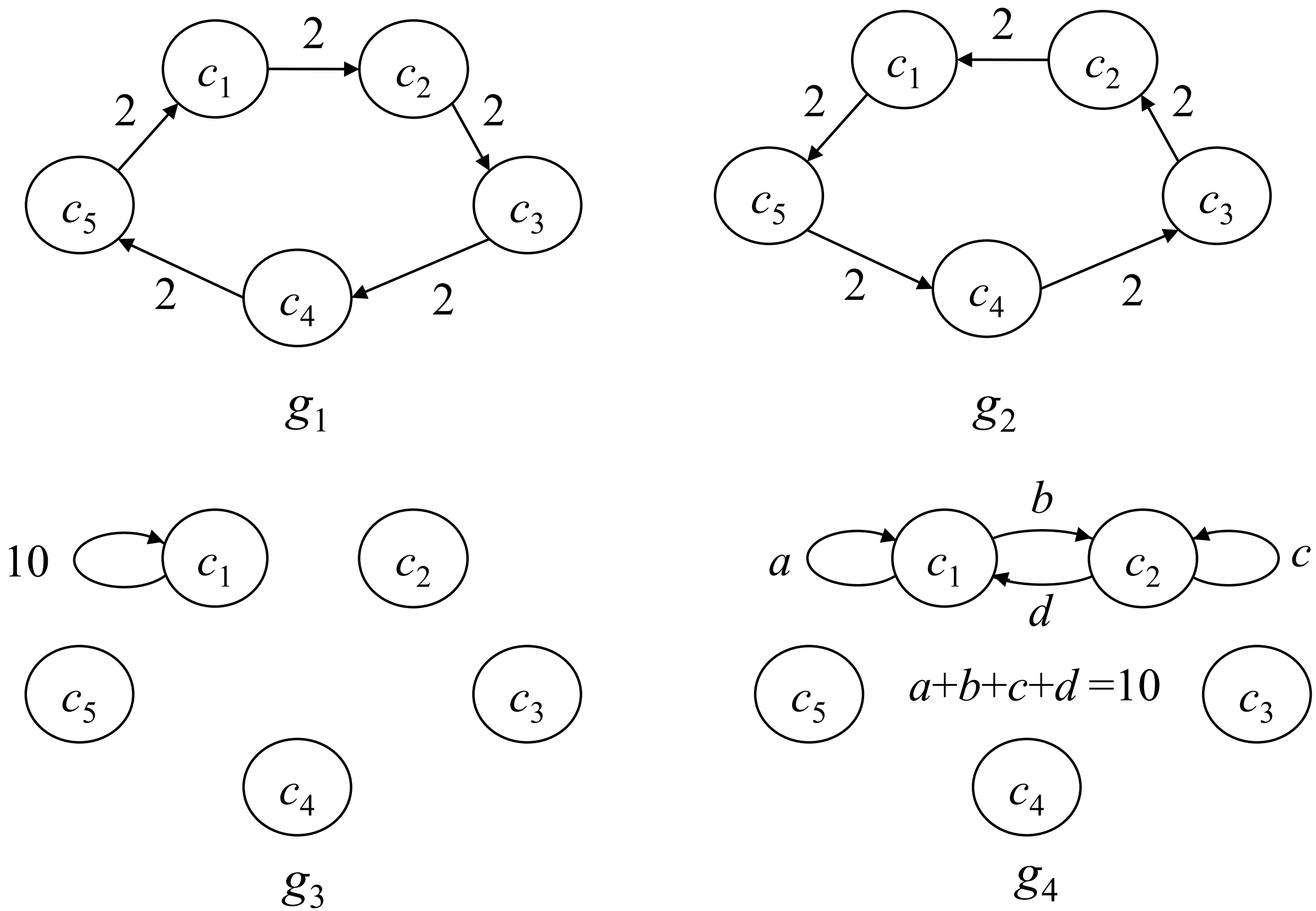
Time(sec.)	Rules
$0 \sim 1999$	R_1. $P_1 \sim P_3$: $1 \to 2 \to 3 \to 4 \to 5 \to 1 \to \cdots$
$2000 \sim 3999$	R_2. $P_1 \sim P_3$: $1 \to 5 \to 4 \to 3 \to 2 \to 1 \to \cdots$
$4000 \sim 5999$	R_3. $P_1 \sim P_3$: Move rooms $1 \sim 5$ randomly.
$6000 \sim 7999$	R_4. $P_1 \sim P_3$: Move room1 $1 \sim 3$ randomly.

n_1 (the number of Phase I clusters) $= 5$, n_2 (the number of Phase II clusters) $= 4$, $L = 50$ (sec.), $m = 10$.



Success

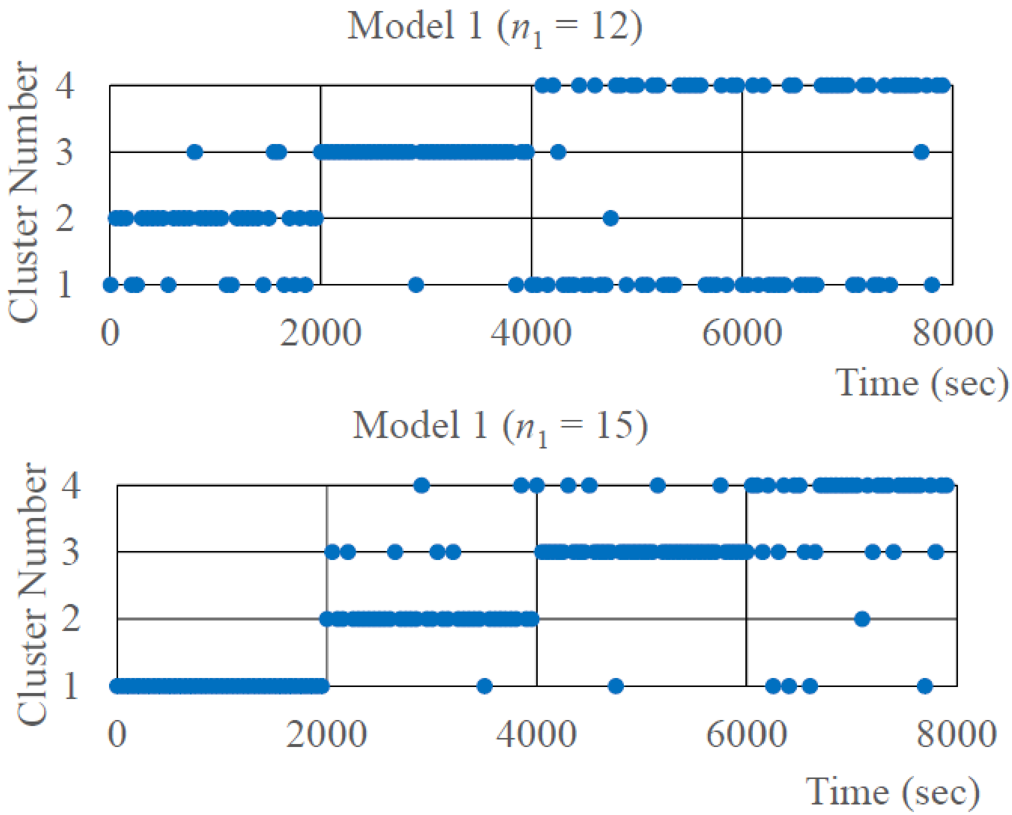
Simple Model 1



Scene Transition Graphs at Phase II

Simple Model 1 with Noise

- 70% $\rightarrow$ Main rule, 30% $\rightarrow$ Other three rules
  n_1 (the number of Phase I clusters) ≥ 5, n_2 (the number of Phase II clusters) $= 4$, $L = 50$ (sec.), $m = 10$.



Larger n_1 is needed.

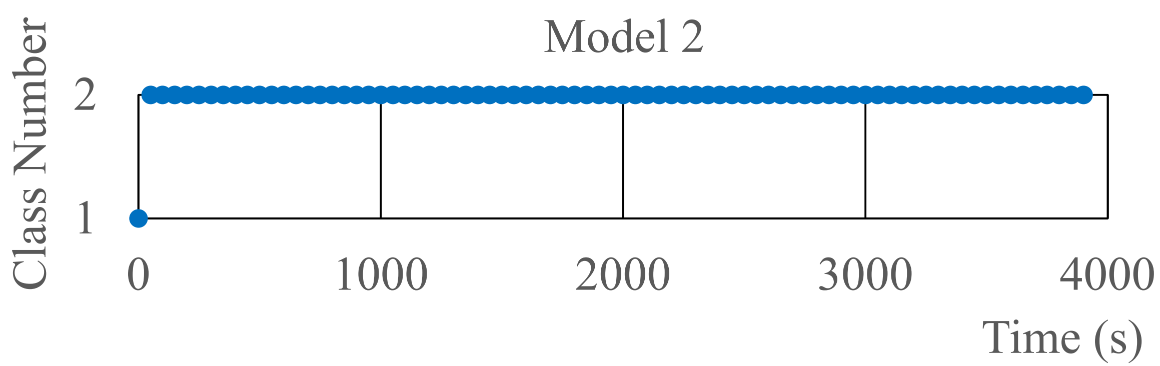
Simple Model 2

- There are five rooms 1 - 5 and three persons P_1, P_2, P_3.

Model 2

Time(sec.)	Rules
$0 \sim 1999$	R_5. $P_1: 1 \to 2 \to 3 \to 4 \to 5 \to 1 \to \cdots$ $P_2: 2 \to 3 \to 4 \to 5 \to 1 \to 2 \to \cdots$ $P_3: 3 \to 4 \to 5 \to 1 \to 2 \to 3 \to \cdots$
$2000 \sim 3999$	R_6. $P_1: 1 \to 3 \to 3 \to 5 \to 5 \to 2 \to \cdots$ $P_2: 2 \to 2 \to 4 \to 4 \to 1 \to 1 \to \cdots$ $P_3: 3 \to 4 \to 5 \to 1 \to 2 \to 3 \to \cdots$

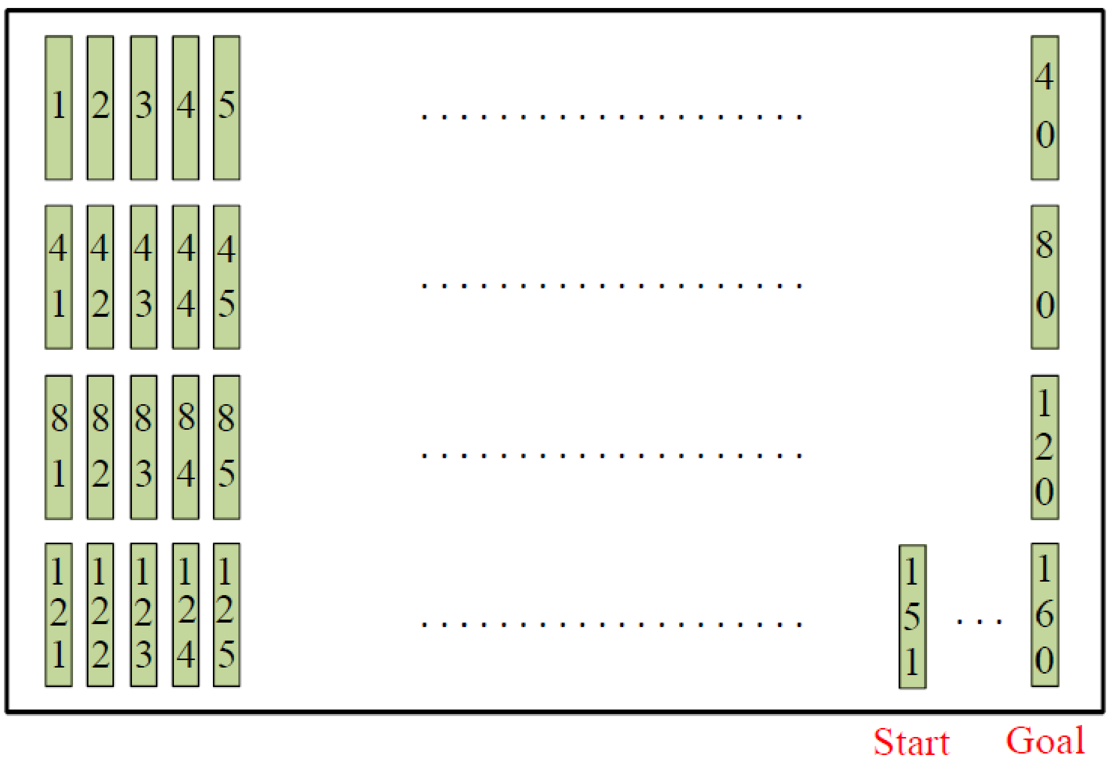
n_1 (the number of Phase I clusters) $= 5$, n_2 (the number of Phase II clusters) $= 2$, $L = 50$ (sec.), $m = 10$.



Failure. Two rules give the same time series of place vectors.

Picking in Warehouse

- There are 30 persons working in a warehouse. At each round, each person starts from START, picks goods on shelves, and return to GOAL.



Picking in Warehouse 1

- Rules

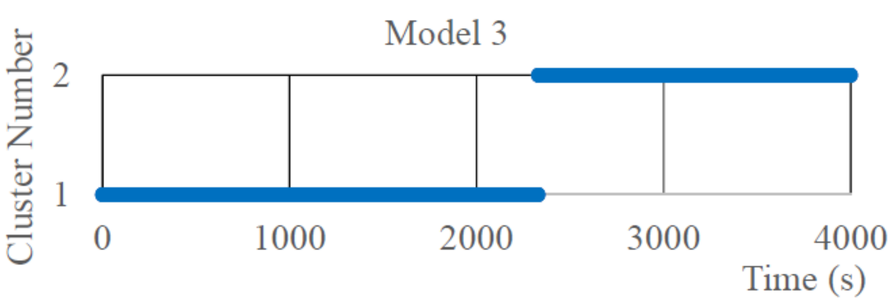
Model 3

Time(sec.)	Rules
$0 \sim 1999$	R_7. All: At each round, choose 5 shelves randomly from 1-80 and visit them by a random route.
$2000 \sim 3999$	R_8. All: At each round, choose 5 shelves randomly from 81-160 and visit them by a random route.

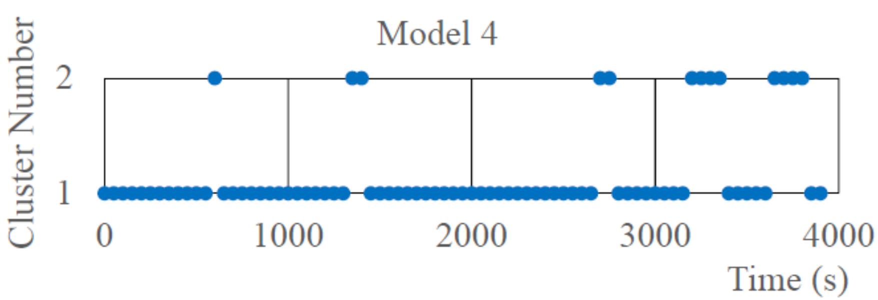
Model 4

Time(sec.)	Rules
$0 \sim 1999$	R_9. All: At reach round, choose 5 shelves randomly and visit them by shortest routes.
$2000 \sim 3999$	R_{10}. All: At reach round, choose 5 shelves randomly and visit them by random routes.

n_1 (the number of Phase I clusters) $= 10$, n_2 (the number of Phase II clusters) $= 2$, $L = 50$ (sec.), $m = 10$.



Success



Failure

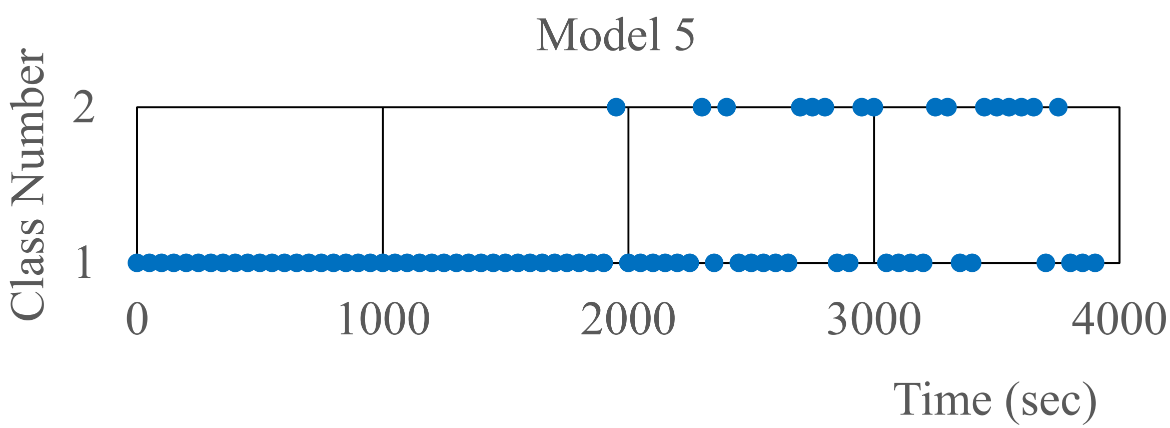
Picking in Warehouse 2

- Rules

Model 5

Time(sec.)	Rules
$0 \sim 1999$	R_{11}. All: Move to 1 ~150 randomly.
$2000 \sim 3999$	R_{12}. All: Move to a shelf within 3 shelves from the current location randomly.

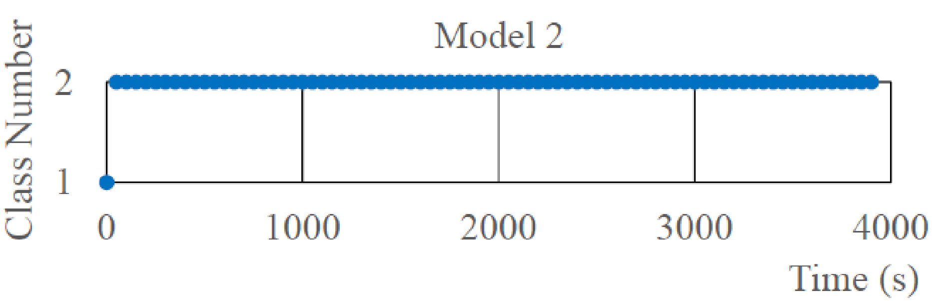
n_1 (the number of Phase I clusters) = 10, n_2 (the number of Phase II clusters) = 2, L = 50 (sec.), m = 10.



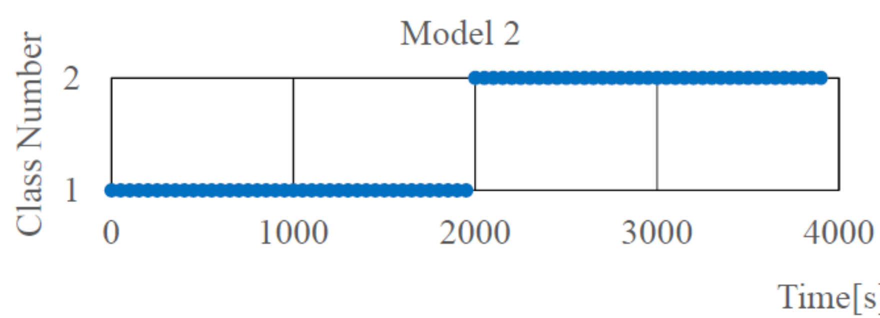
Two rules are not separated clearly, but the change point is detected.

Improvement

- *Direction vector* $v = [v_{ij}]$, where v_{ij} is the number of persons that move from region $_i$ to region j if $i \neq j$, and the number of persons stay at region i if $i = j$.
- Since the dimension of the vector is r^2, where r is the number of regions, we may apply PCA(Principal Component Analysis) to the vectors.



Place vector



Direction vector

Conclusion

- The proposed method does not work well if the action rules give similar sequences of place vectors $\rightarrow$ Direction vectors + PCA.
- Other improvements
  - Using Staff ID (= distinguishing individual persons) with data structure that is invariant for exchanging IDs.
  - Adding other statistics on movement

Thanks to Shun Hayakashi!