Calculation of Location Probabilities for Agent-based Target Tracking System

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The Sixteenth International Conference on Networking and Services ICNS 2020
September 27, 2020 to October 01, 2020 - Lisbon, Portugal

Presenter Resume

Masaru Shiozuka

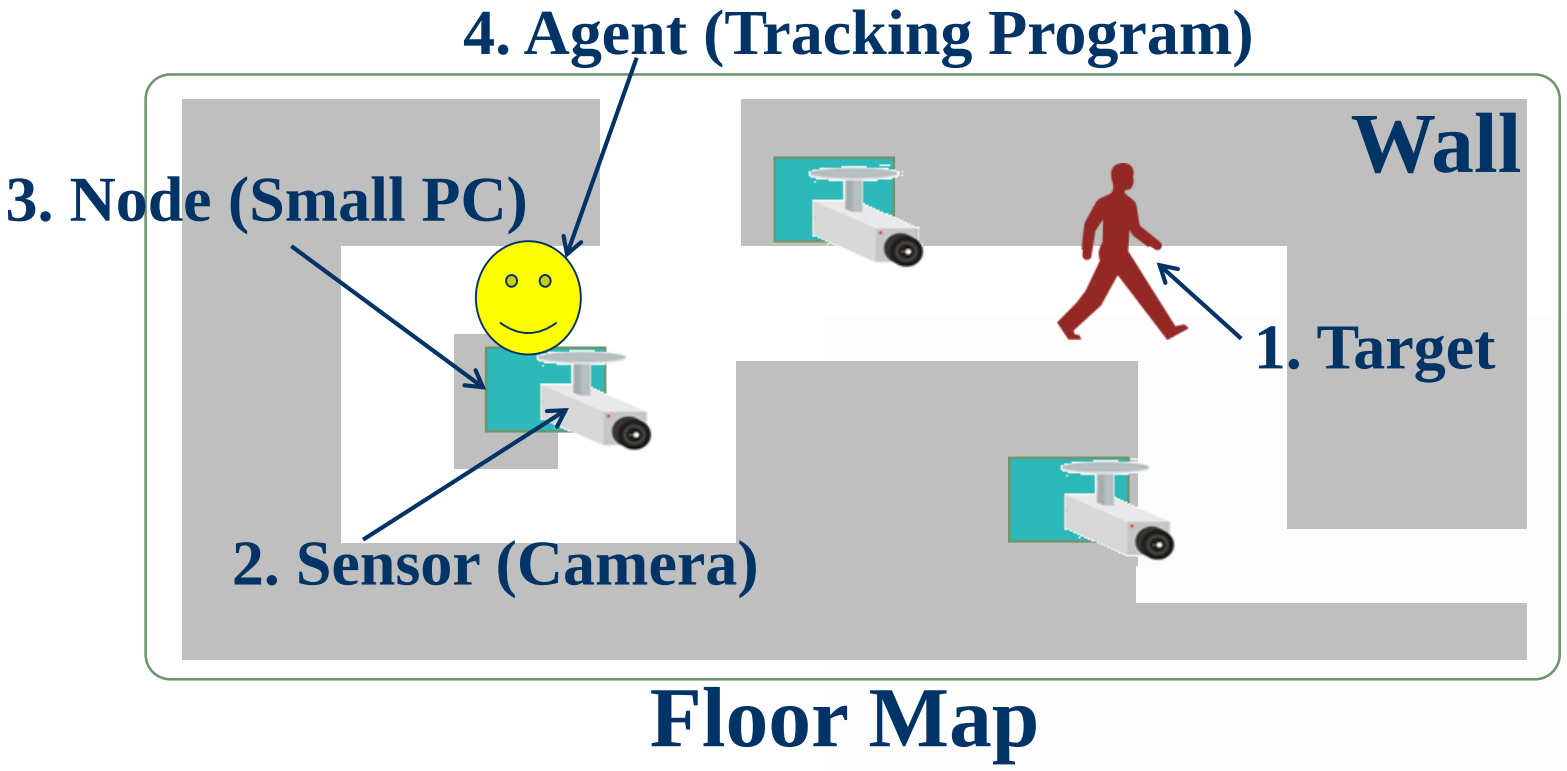
received the B.E. and M.E. degree in Artificial Intelligence and Computer Science from the Kyusyu Institute of Technology in 2009 and 2011, respectively. Since 2011 he has worked at System Engineering Department, Melco Power Systems Co. Ltd. He is currently pursuing the D.E. degree with the Department of Information and Electronics, Graduate School of Engineering, Tottori University. His research interests include video monitoring system, geographic system and target tracking system.

Outline

1. Agent Based Target Tracking System
2. Issues to be Addressed
3. Calculation of Probabilities in Group
4. Experiments
5. Conclusion and Future Work

1. Agent Based Target Tracking System

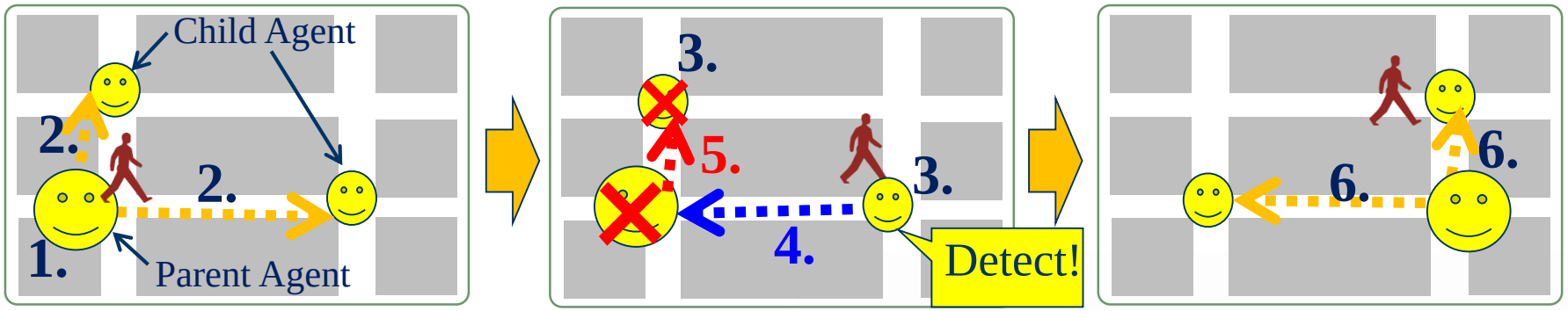
System Overview



1. Agent Based Target Tracking System

Tracking Flow

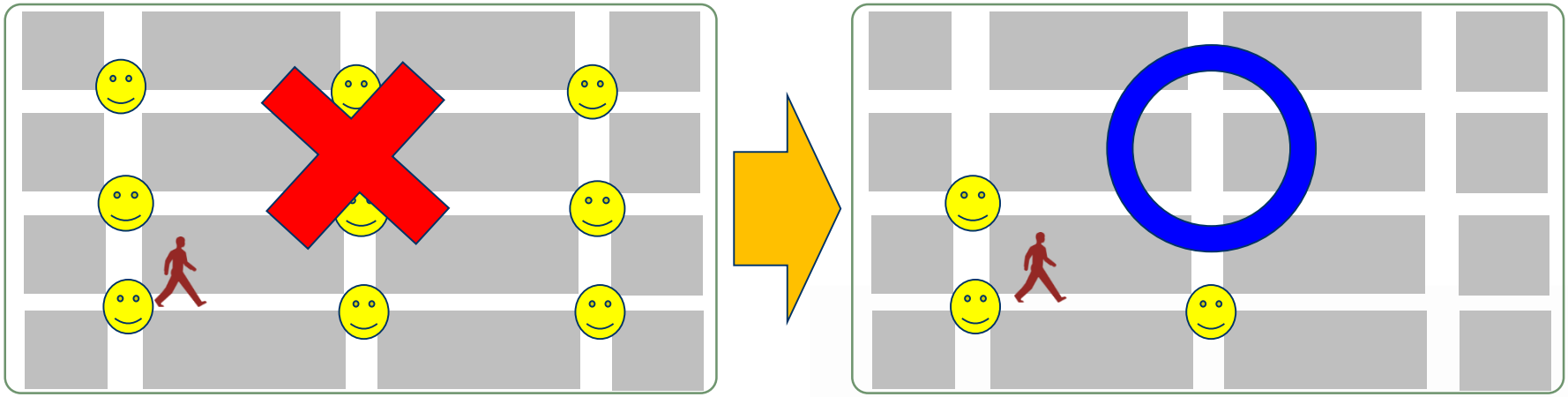
A target is tracked as the following 1st to 6th steps.



1. An operator sends an agent. We call this agent a "parent agent."
2. The agent creates its copies and sends them to neighbor relations nodes. We call these agents "child agents."
3. Child agents collect images from camera.
4. The child agent notifies the target detection to the parent agent.
5. The parent agent notifies the target detection to all child agents, and exits itself.
6. The child agent who detects the target becomes a new parent agent and goes to step 2.

1. Agent Based Target Tracking System

Neighbor Relations Nodes



Waste resource!

It is waste to send child agents to all nodes on a floor.

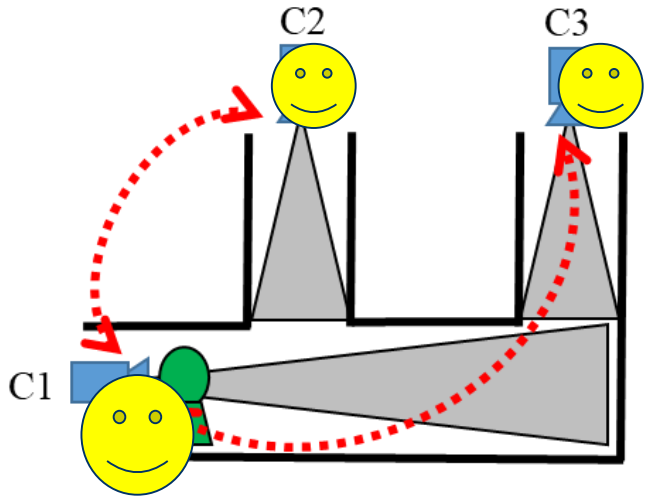
Efficiently Use Resouces!

Child agents are only sent to neighbor relations nodes where a target is predicted to be detected next.

1. Agent Based Target Tracking System

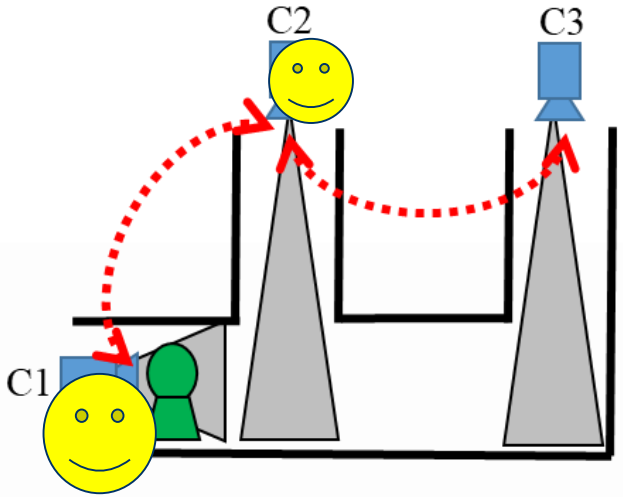
Neighbor Relations Nodes Example

C1 and C2 are neighbor cameras.
C1 and C3 are neighbor cameras.



Parent agent sends two child agents to C2 and C3 respectively.

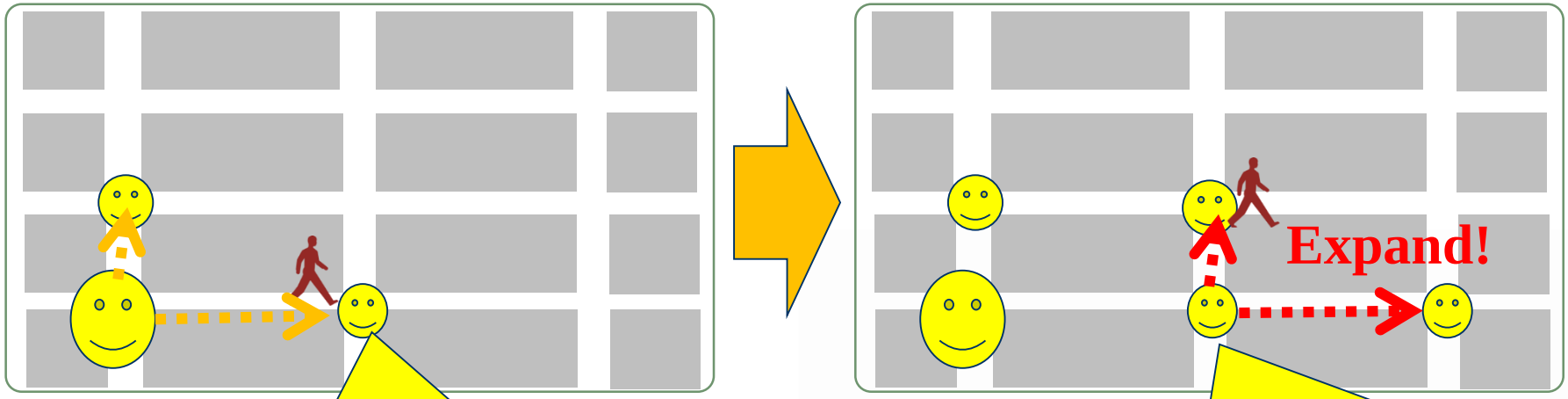
C1 and C2 are neighbor cameras.
C2 and C3 are neighbor cameras.



Parent agent sends a child agent only to C2 because the agent at C2 can detect a target before the target reaches C3.

2. Issues to be Addressed

Not only a parent agent but also a child agent can send its copies agents.

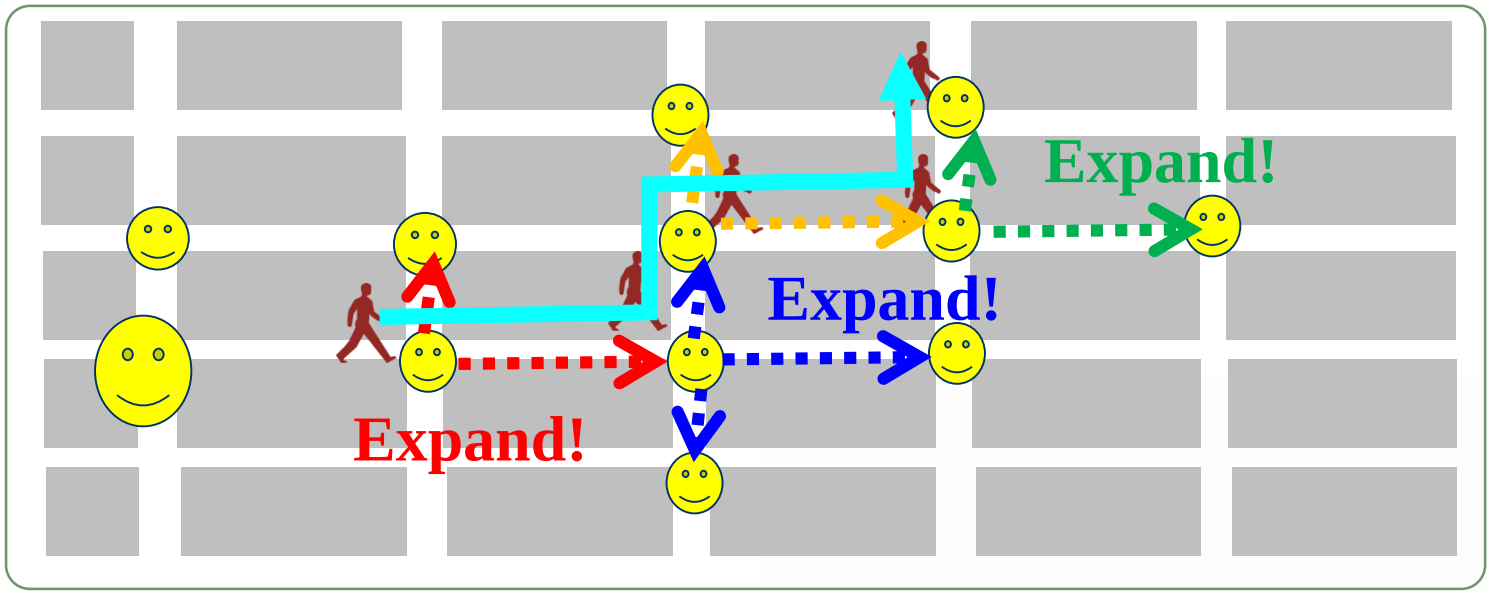


Might be target but not enough evidence…

Creates its copies and send them to neighbor relation nodes and re-evaluate the person at new nodes.

2. Issues to be Addressed

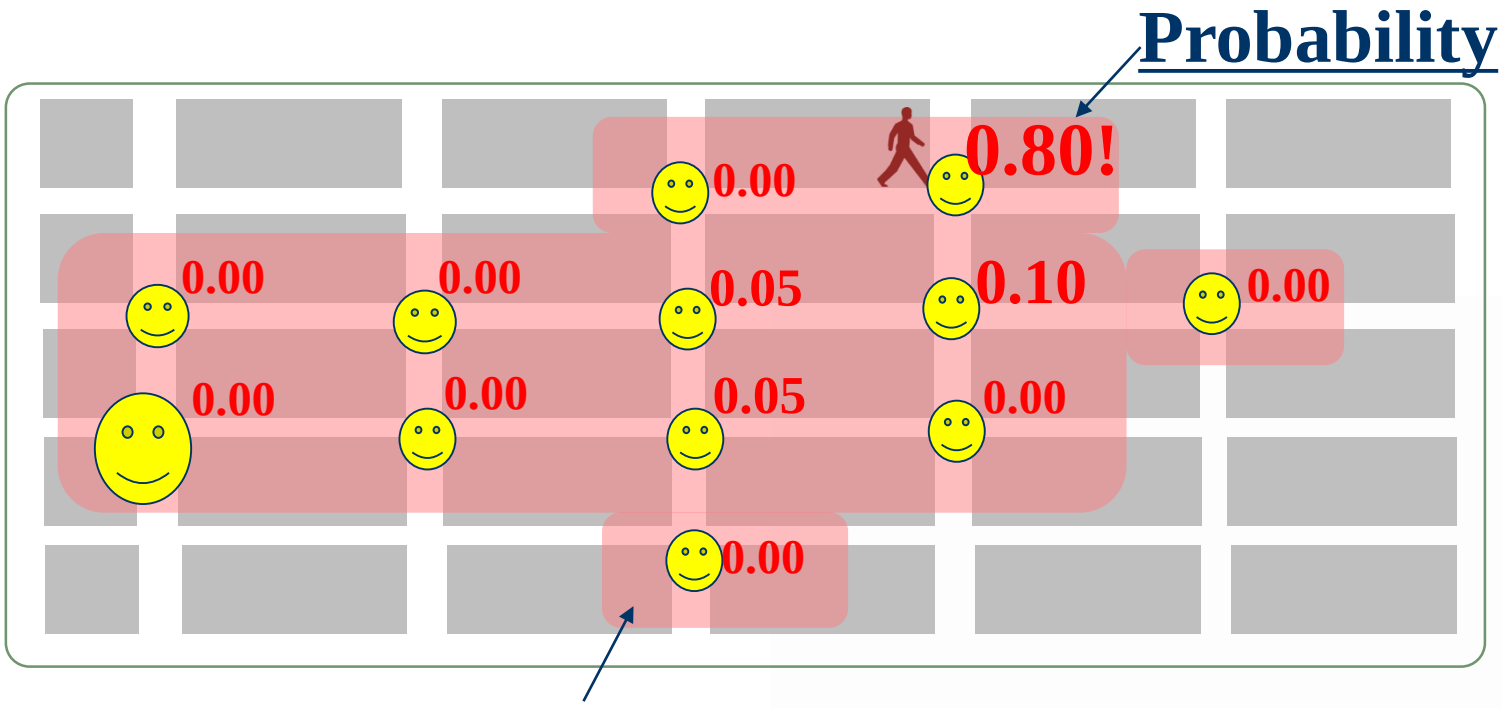
Issue: No mechanism to suppress expansion...



When expansions occur repeatedly, it increases the number of agents on the floor.

2. Issues to be Addressed

Solution: Calculates probabilities of where a target is within a group. Make it easy to know where a target is.



3. Calculation of Probabilities in Group

How to Calculate Probabilities in Group

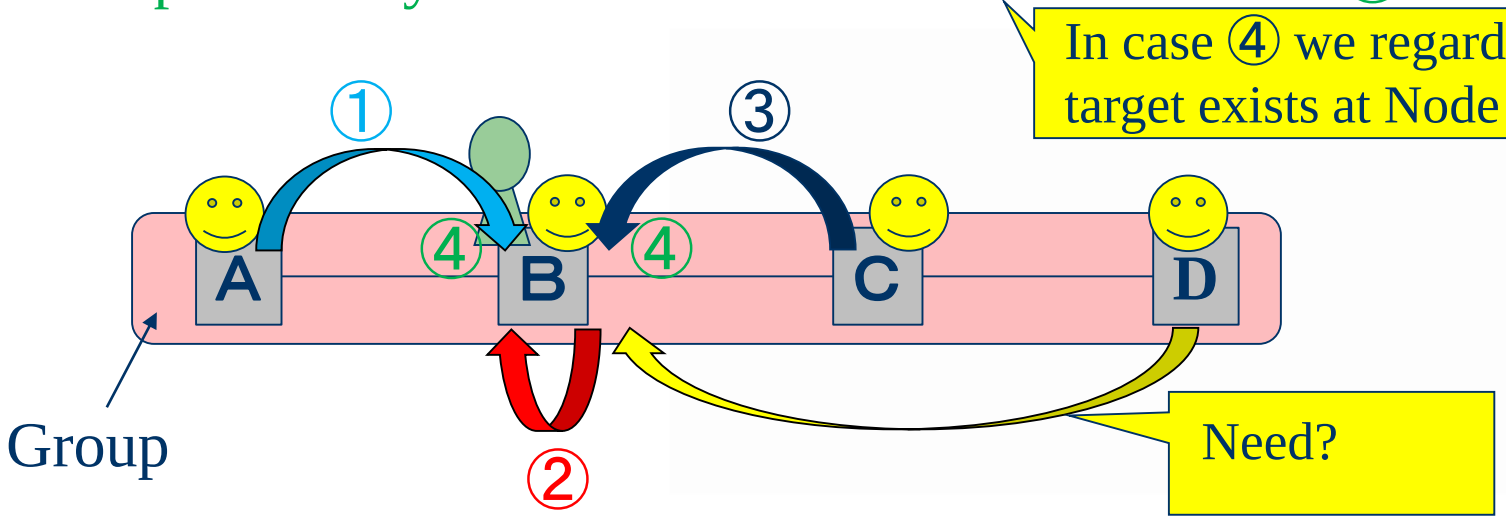
The probability that a target exists at node B

= The move probability: node A to node B - ①

+ The move probability: node B to node B - ②

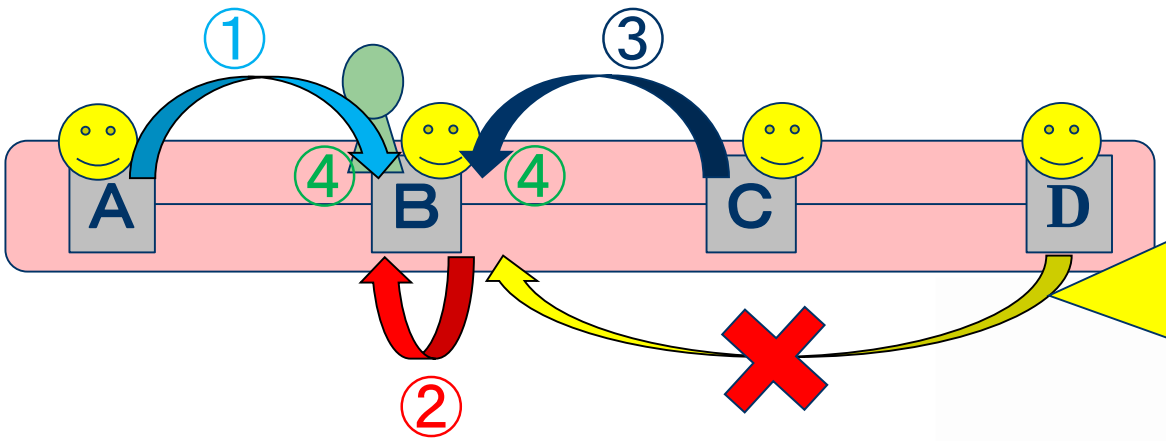
+ The move probability: node C to node B - ③

+ The probability: around node B but not observed - ④



3. Calculation of Probabilities in Group

When a target exists at node B, the target cannot reach node D, without passing node C.



Needless to consider the case of movement from node D to node B because the case is summarized the movement from node C to node B ③.

Approach:

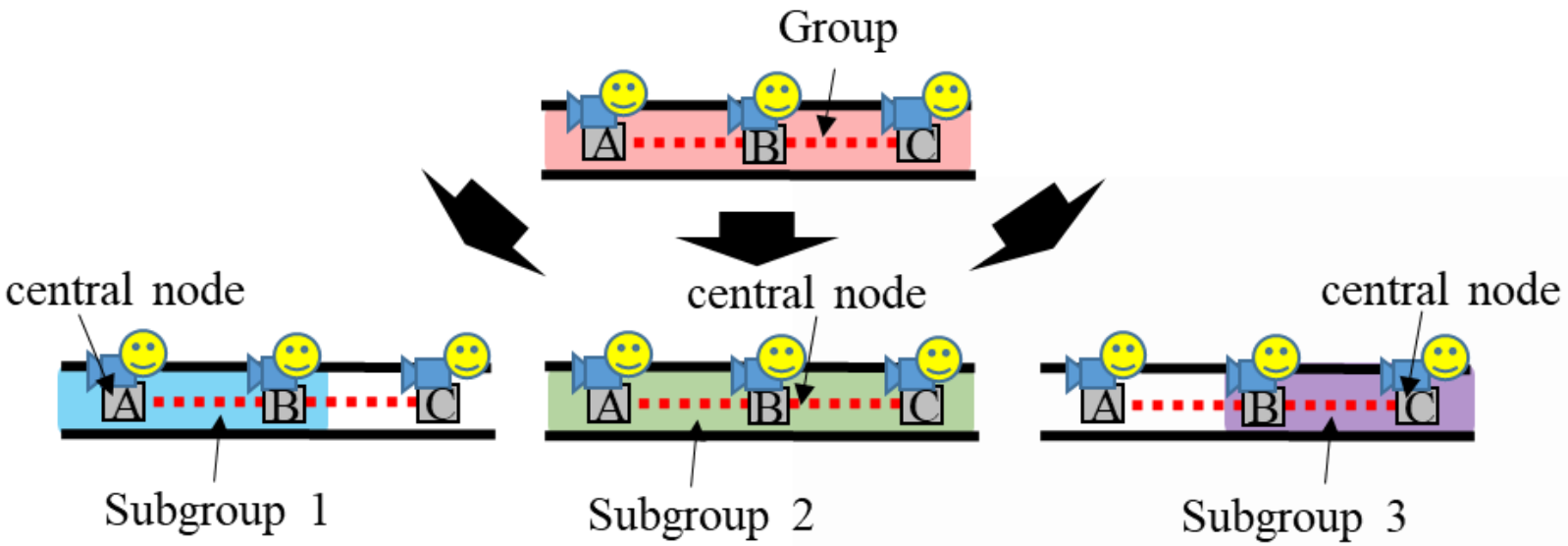
First, we calculate the probabilities that the target will move from a node to its neighbor relation nodes. For this calculation, we divide a group into subgroups.

Then, the probabilities of each node in a group are calculated by integrating the probabilities of each node in the subgroups.

3. Calculation of Probabilities in Group

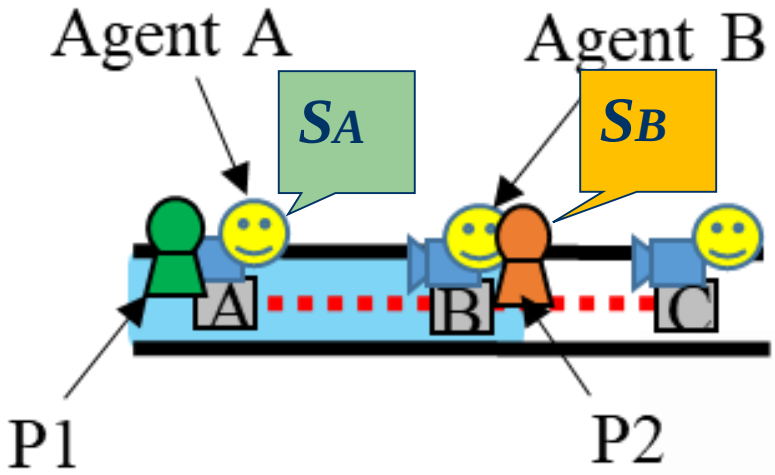
Divides a group into subgroups

Subgroup: A set of nodes comprised of a central node and its neighbor relation nodes.



3. Calculation of Probabilities in Group

Probabilities in Subgroup



S_A/S_B is a probability that the agent at node A/B regards a person on the node as the target.

Probability of P1 is a target: $S_A \times (1-S_B)$
Probability of P2 is a target: $(1-S_A) \times S_B$
Probability that neither P1 nor P2 is a target: $(1-S_A) \times (1-S_B)$

3. Calculation of Probabilities in Group

Probabilities in Subgroup

When *n* nodes in a subgroup.

Probability that a person detected at node *m* is a target:

$$s_m \times \prod_{\substack{i=1 \\ i \neq m}}^{n} (1 - s_i) \quad \times \alpha$$

Probability that the target is not observed by any nodes in the subgroup:

$$\prod_{i=1}^{n} (1 - s_i) \quad \times (1\text{-}\alpha)$$

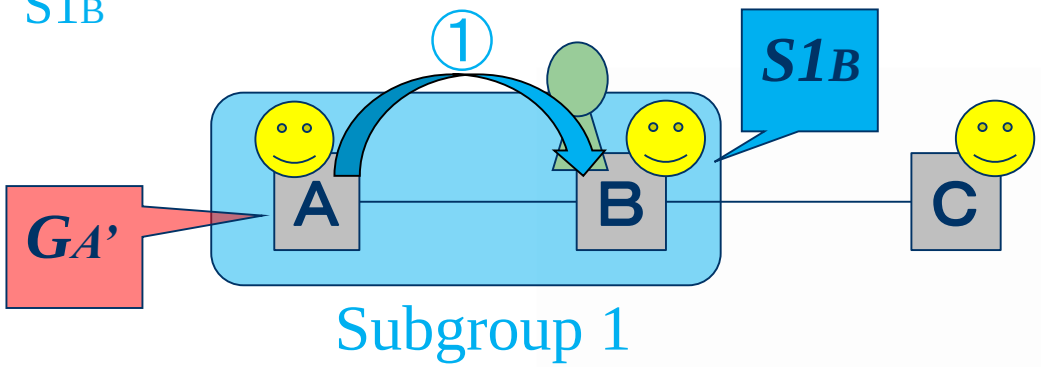
We introduced a probability α that a target can be observed. This is because a case that a target exists between nodes but the target is not observed can occur. We think the possibility of observing the target decreased if the distance between the nodes is significant.

3. Calculation of Probabilities in Group

Probabilities in Group

By integrating the probabilities of each node in the subgroups, the probabilities of each node in a group are calculated.

The move probability node A to node B①
= Probability that the target was at node A × the target is now node B
= $G_{A'}$ × $S1_B$

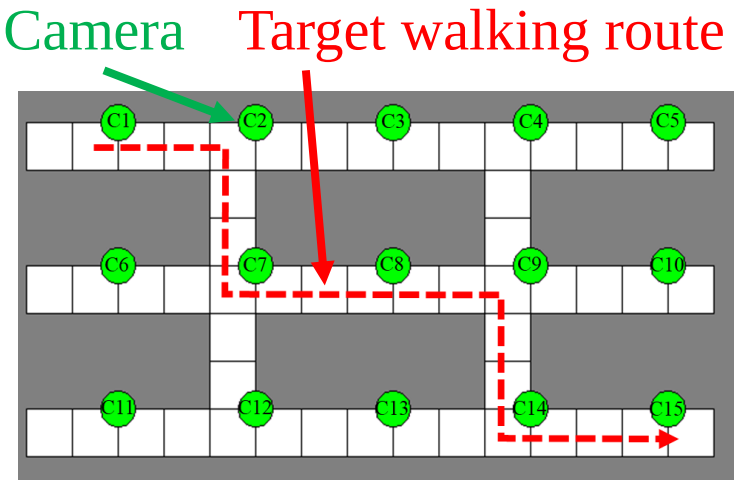


Subgroup 1

Also, the other movement of ②③④ probabilities are calculated by multiplying the previous probability by the current probability.

4. Experiments

A simulation environment was implemented to evaluate the proposed method.



Floor Map

TargetID	Walking Route
P1, P5	C1→C2→C7→C8→C9→C14→C15
P2, P6	C11→C12→C7→C8→C9→C4→C5
P3, P7	C5→C4→C9→C8→C7→C12→C11
P4, P8	C15→C14→C9→C8→C7→C2→C1

Walking routes of P1 to P8. A maximum of eight targets are assumed to be walking at the same time.

4. Experiments

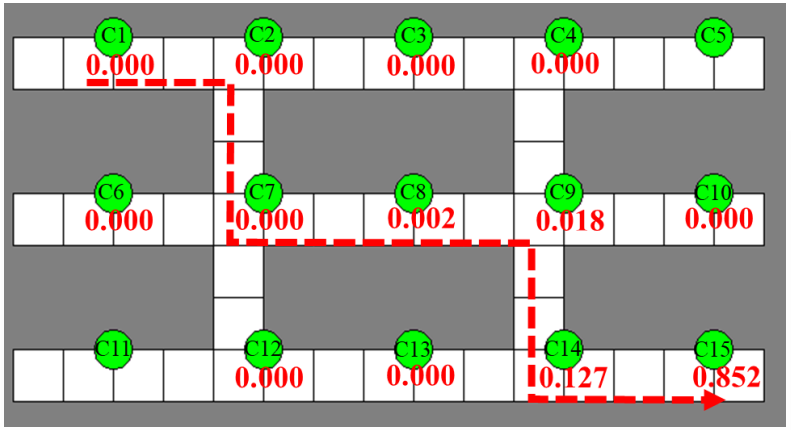
Tracking Result of One Person

A target moved between the cameras in the order of C1→C2→C7→C8→C9→C14→C15.

Probabilities of each node in each time period.

Camera No.	t=0	t=4	t=8	t=12	t=16	t=20	t=24
C1	*1.000*	*0.072*	*0.005*	*0.001*	0.000	0.000	0.000
C2	0.000	*0.928*	*0.071*	*0.008*	*0.001*	0.000	0.000
C7	0.000	0.000	*0.924*	*0.101*	*0.012*	*0.002*	0.000
C8	0.000	0.000	0.000	*0.890*	*0.106*	*0.015*	*0.002*
C9	0.000	0.000	0.000	0.000	*0.881*	*0.122*	*0.018*
C14	0.000	0.000	0.000	0.000	0.000	*0.862*	*0.127*
C15	0.000	0.000	0.000	0.000	0.000	0.000	*0.852*

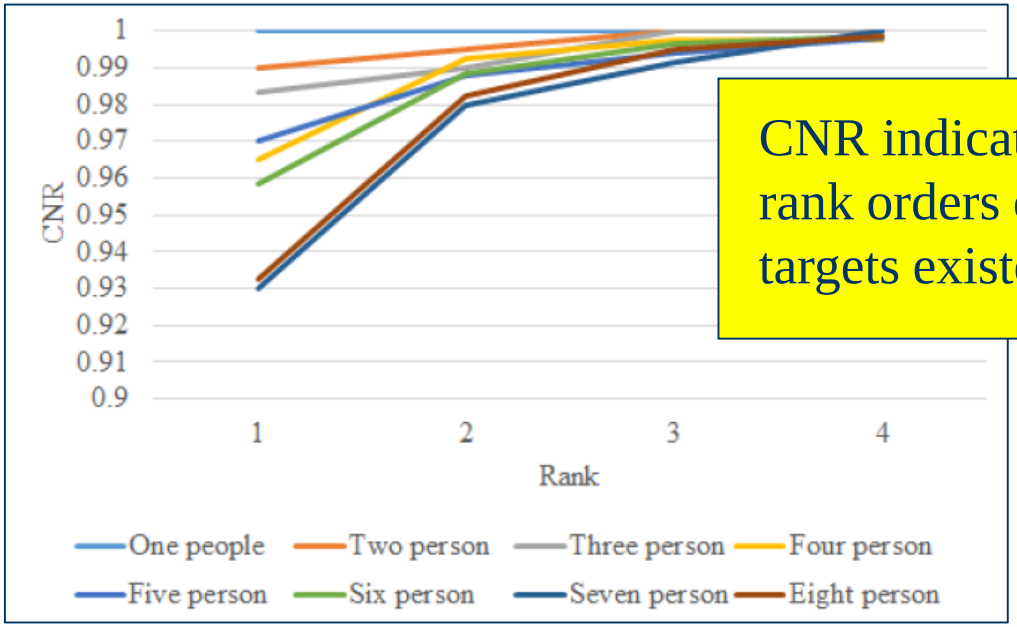
Snapshot of when target reached the goal, C15.



The results show that the probabilities changed according to the movement of the target, and the tracking was successful.

4. Experiments

Tracking Result of Eight Person

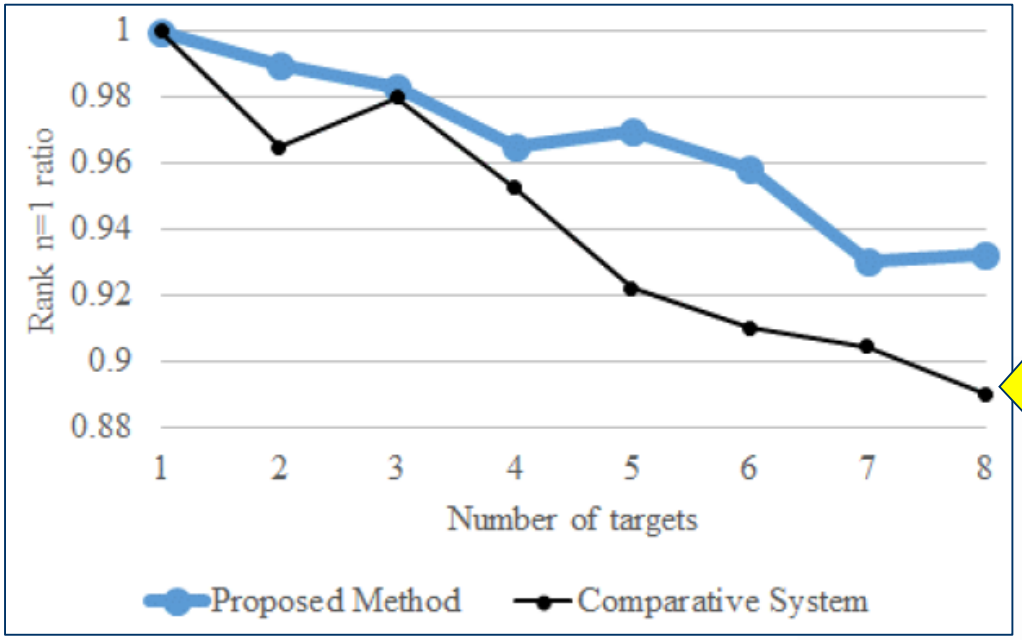


CNR indicates the rank orders of a node targets existence.

The results shows 93% of targets existed on the node of 1st rank, and 99% exited at the 4th rank.

4. Experiments

Tracking Result of Eight Person



A comparative system regards a person with the highest probability as the target.

The results shows the proposed method tracks with a higher accuracy rate than the comparative system.

5. Conclusion And Future Work

- Conclusion

  We proposed a method to calculate the probabilities of the location of a target in a group of agents.

- Future Work

  We plan to evaluate the validity of the proposed method in an actual environment.

Thank you very much.