A Multi-Agent Approach for Evacuation Support Systems

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Short Biography

Dr. YasushiKambayashi is a professor in the Department of Informatics and Data Science from Sanyo-Onoda City University.

He worked at the Nippon Institute of Technology and Mitsubishi Research Institute as an associate professor and staff researcher, respectively, before joining the institute.

He is currently engaging evacuation support systems based on multi-agents and cooperative multiple UAVs.

Background

- Wireless communication using a smartphone may be difficult when a large-scale disaster occurs.
  - Due to traffic congestion and damage of base stations.

- Evacuees require information.
  - Detour route to avoid dangerous point such as fire.

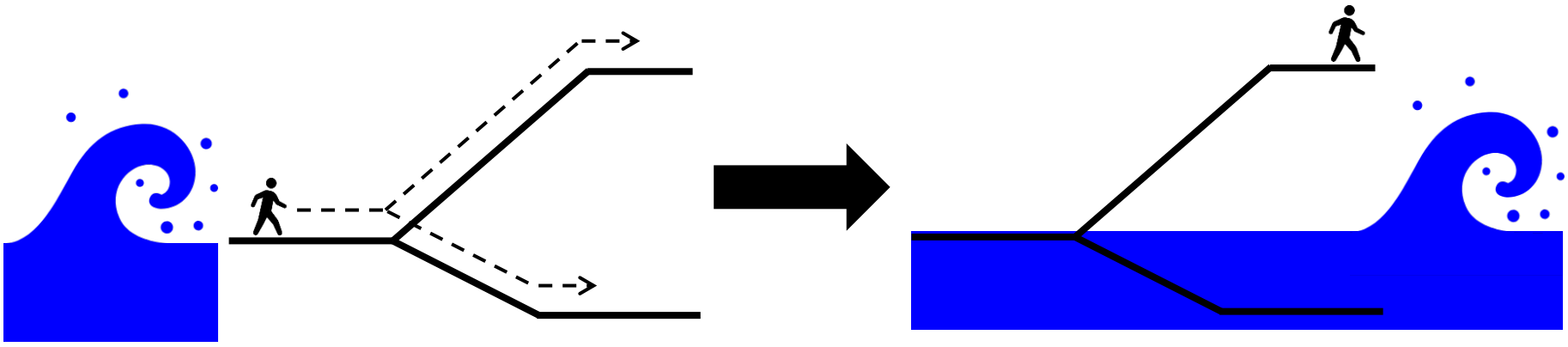
Purpose

- We have proposed this evacuation support system.
  1. Constructing network without communication base station.
  2. Discovering dangerous point, and sharing between evacuees while evacuation.
  3. Calculating safe evacuation route, and presenting to evacuee.

Purpose

- We consider altitude information for constructing evacuation route.

  - Calculating high altitude route to avoid tsunami or flood tide.



Related Technology

- **Mobile Ad Hoc Network (MANET)**
  - It is a wireless network which consists of only portable devices.
  - It can be built even if communication base station is broken.

Related Technology

Software Agent

- It is a program that is autonomous without human operating.
- It interacts with other agents to achieve goal.
- In this study, the agents are roughly divided into two types.
  - The static agent resides on each smartphone.
  - The mobile agent moves between smartphones.

Proposed System

- **Features**

1. The system builds MANET by wireless communication between evacuee's smartphones.
2. The evacuees share position information of dangerous points by using agents.
3. The system calculates and presents dynamically the evacuation route that avoids dangerous points.

Proposed System

- **Evacuation Routing Algorithm**
  - It is determined based on the Dijkstra's algorithm.
  - In order to construct high altitude evacuation route, this proposed system calculate edge weight by dividing distance by altitude of the node.

Agent System

- **Static Agent**
  - Information Agent
  - Node Management Agent
- **Mobile Agent**
  - Information Diffusion Agent
  - Information Collecting Agent

Agent System

- **Information Agent**
  - It is the static agent that resides on each smartphone.
  - It shares information with mobile agents.
  - It calculates and presents an evacuation route to the system user by using shared information.
  - Every time it receives new information, it updates the evacuation route.

Agent System

- **Node Management Agent**
  - It is the static agent that resides on each smartphone.
  - It stores received information from mobile agents at the information table.
  - If the same information already exists in the information table, the node management agent deletes older information.
  - I passes information to the information agent when it requests.

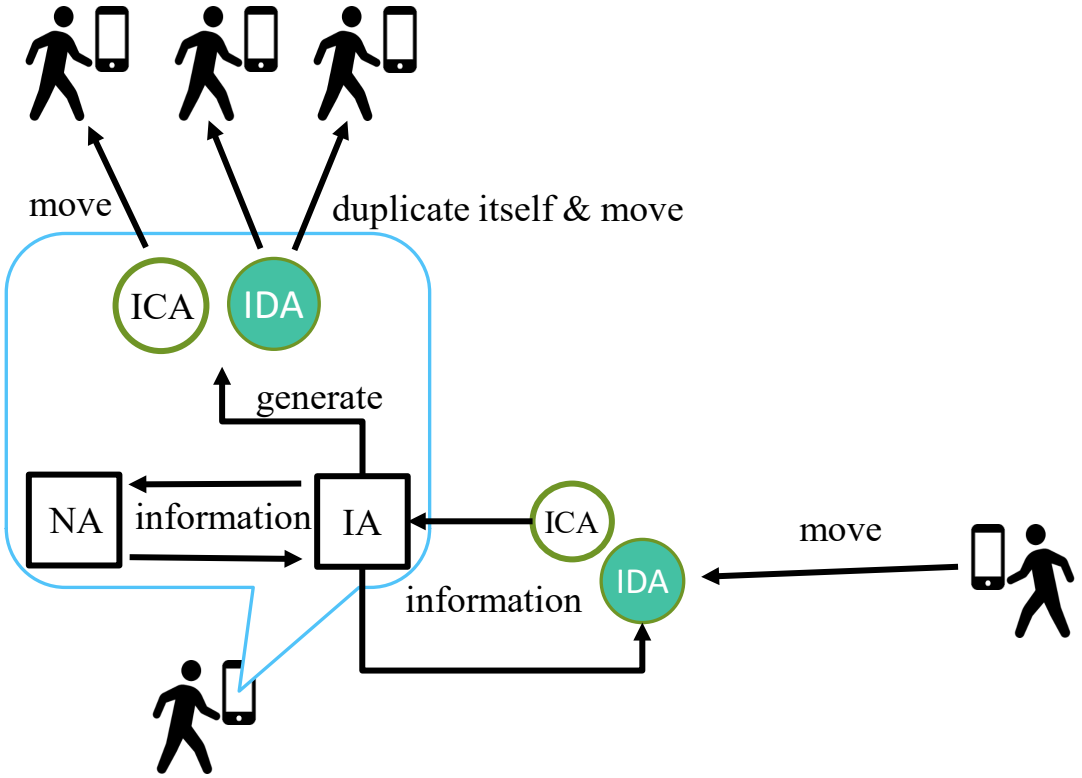
Agent System

- **Information Diffusion Agent**
  - It is the mobile agent that moves between smartphones.
  - It diffuses dangerous point information that system users discover.
  - It duplicates itself and moves with the dangerous point information to all smartphone within communication range, and passes the information.
  - It repeats this process a constant number of hops.

Agent System

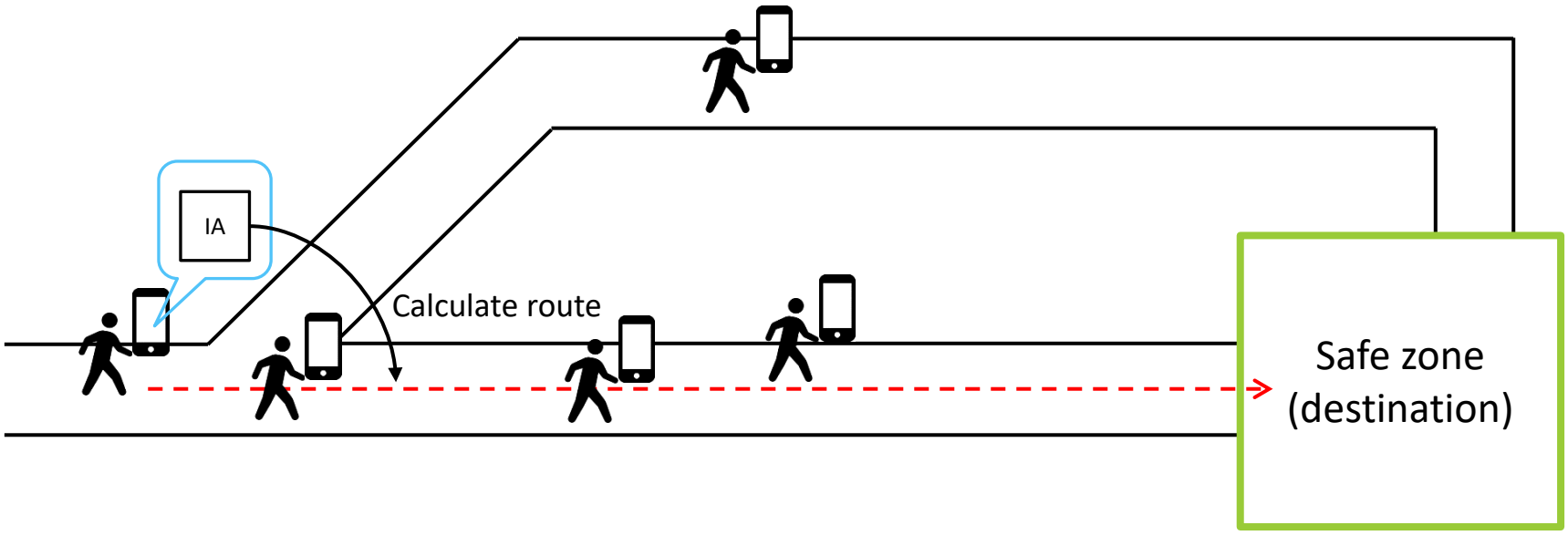
- **Information Collecting Agent**
  - It is the mobile agent that move between the smartphone.
  - It searches dangerous point on owner’s planned evacuation route.
  - If it discovers dangerous point information, it returns to the owner’s smartphone by estimating the current owner's position from the owner’s planned evacuation route, moving speed, and elapsed time.

Agent System



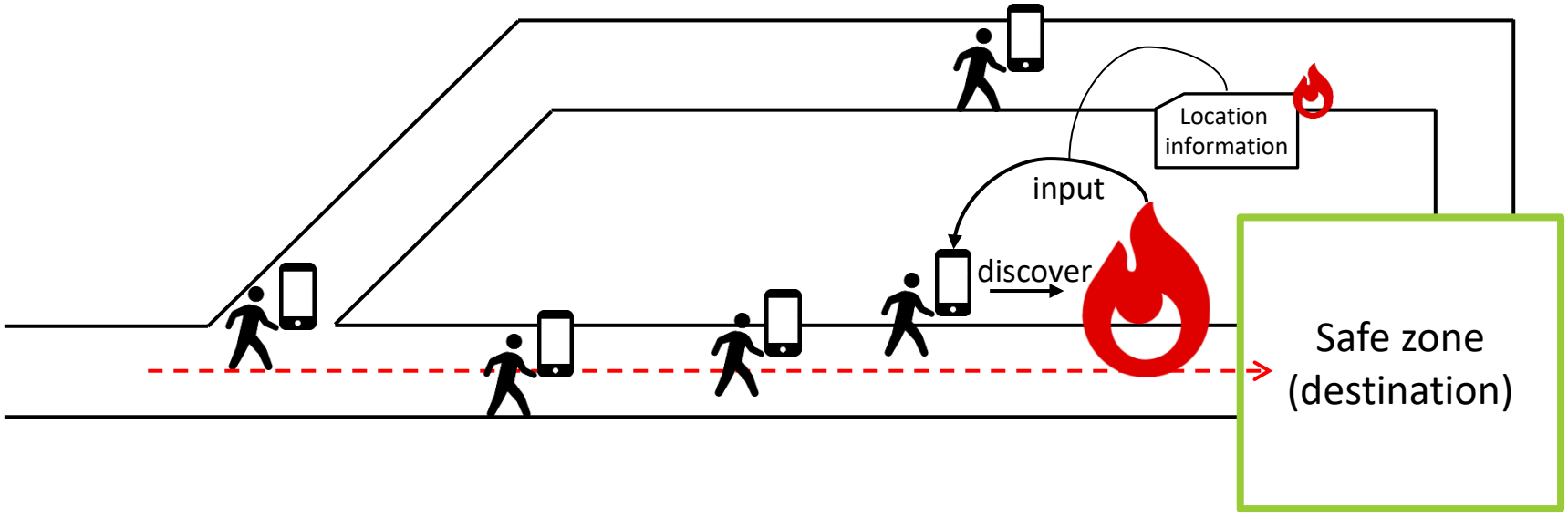
Agent System

- The Information Agent calculates an evacuation, and presents to the system user.

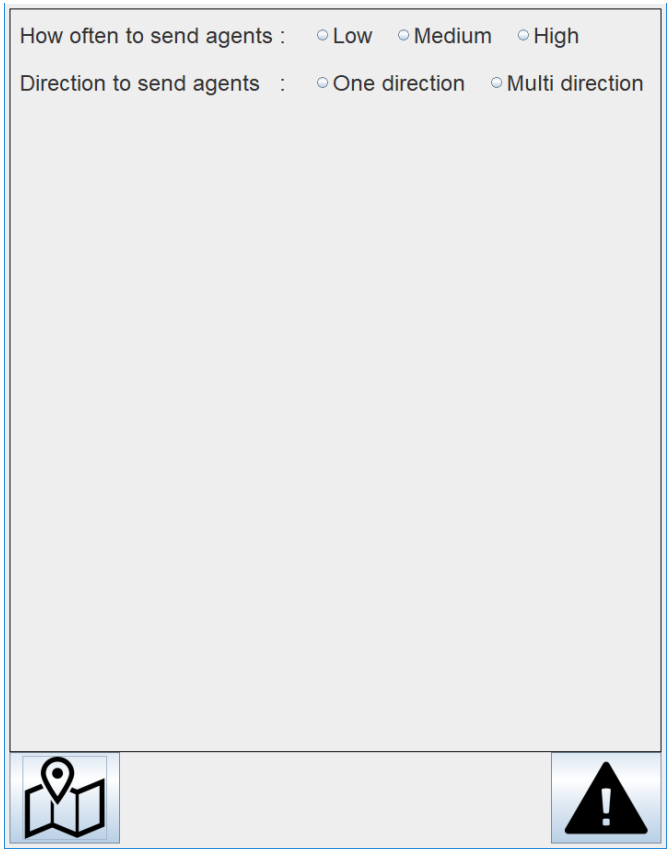


Agent System

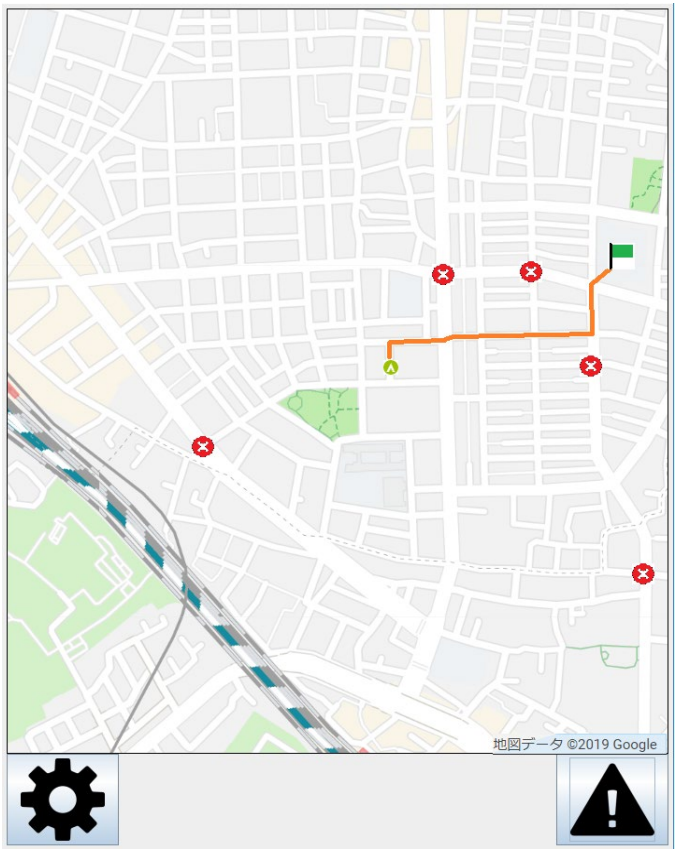
- Someone discovers a dangerous point, inputs the position information of it into the system.



Human Interface



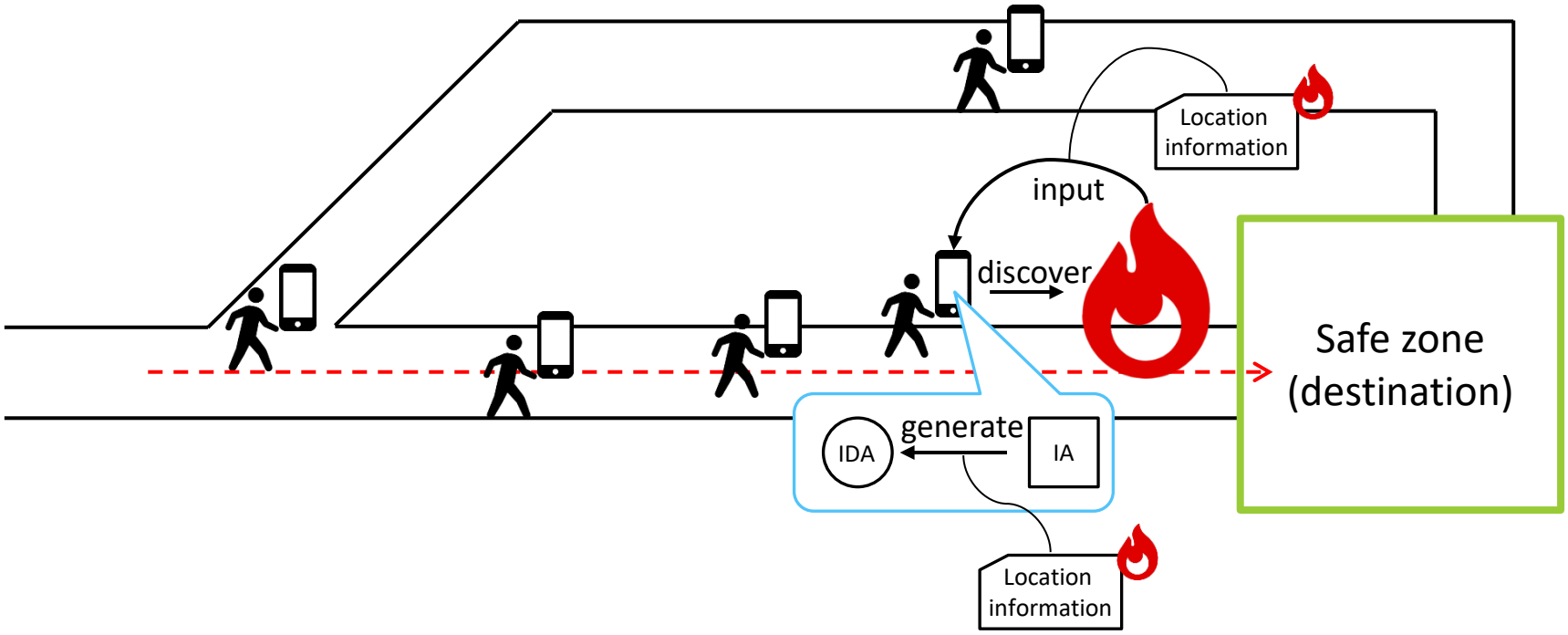
Agent management screen



Guidance screen

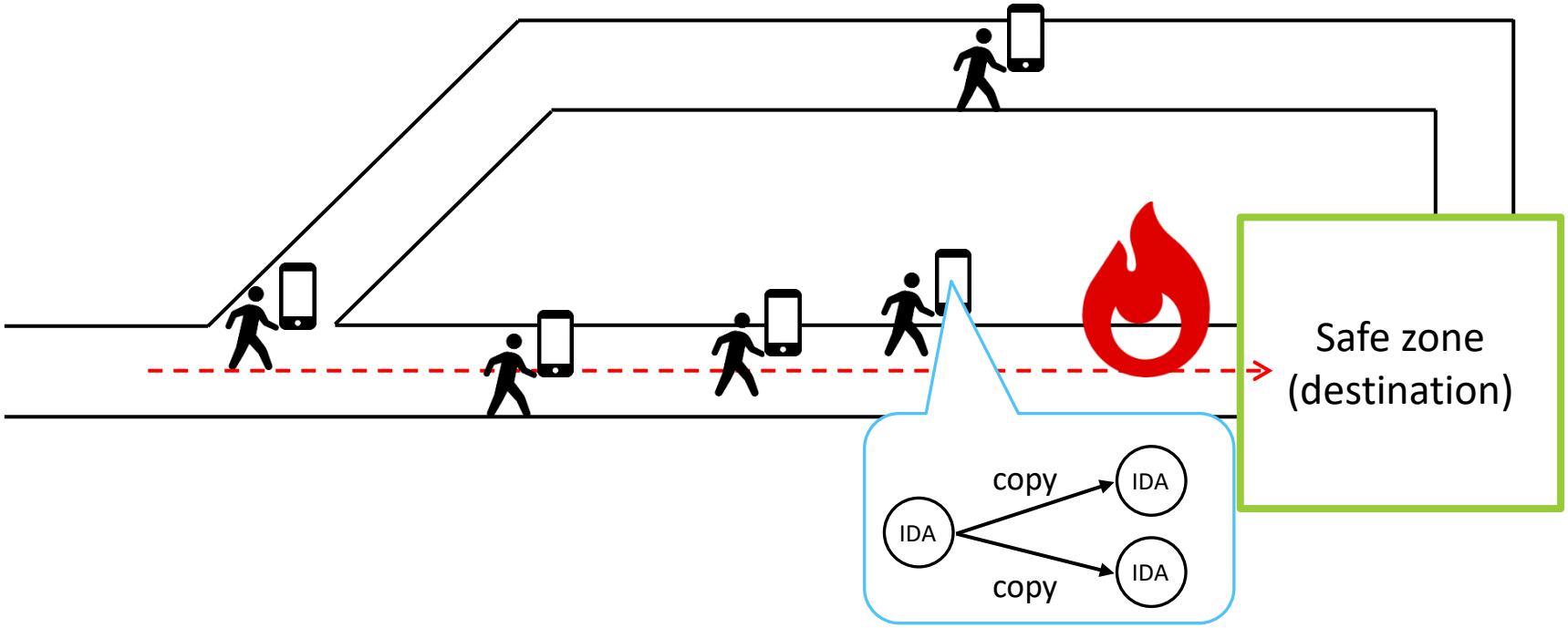
Agent System

- The IA generates the Information Diffusion Agent (IDA) with position information of the dangerous point.



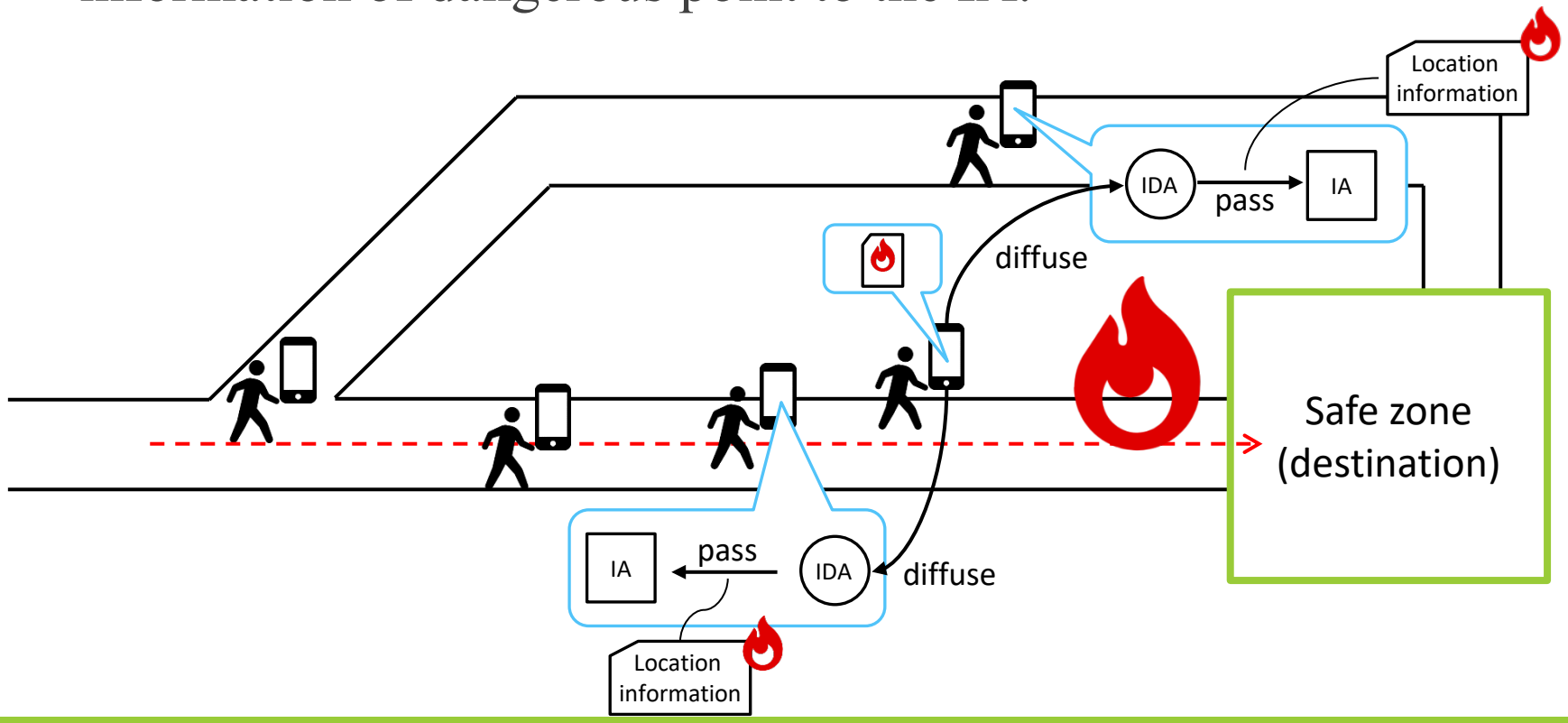
Agent System

- The IDA duplicates itself by the number of smartphones within communication range.



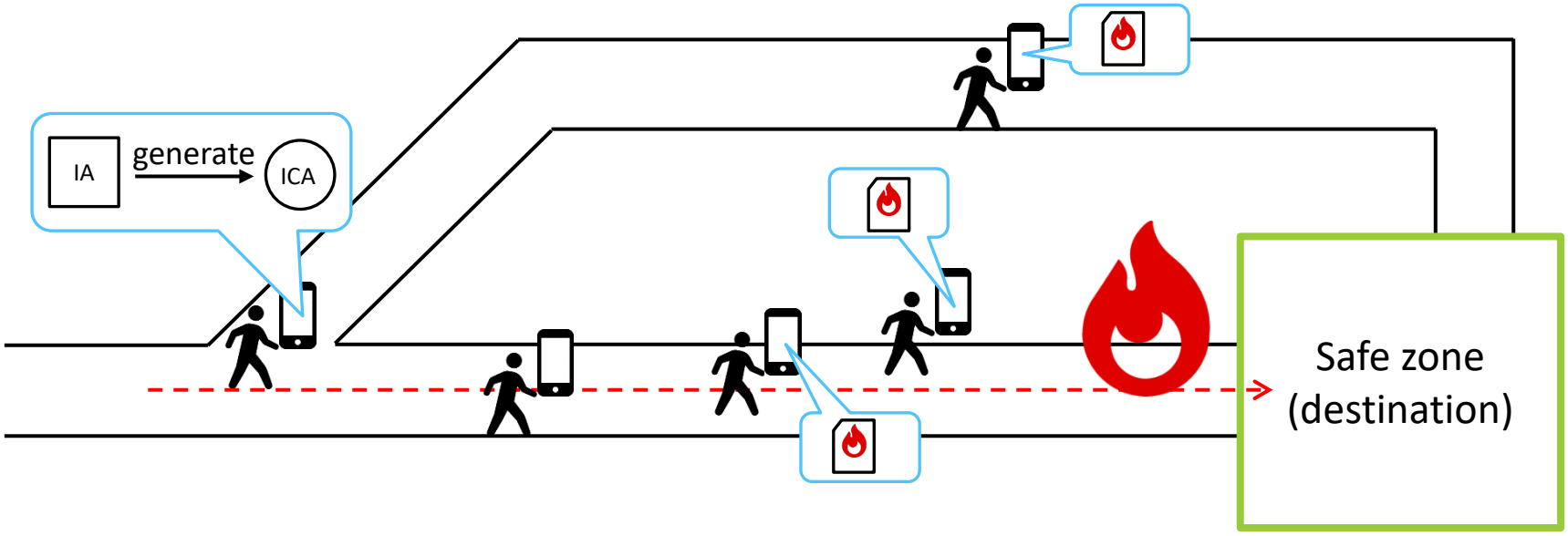
Agent System

- The IDAs move to all smartphones, then pass the position information of dangerous point to the IA.



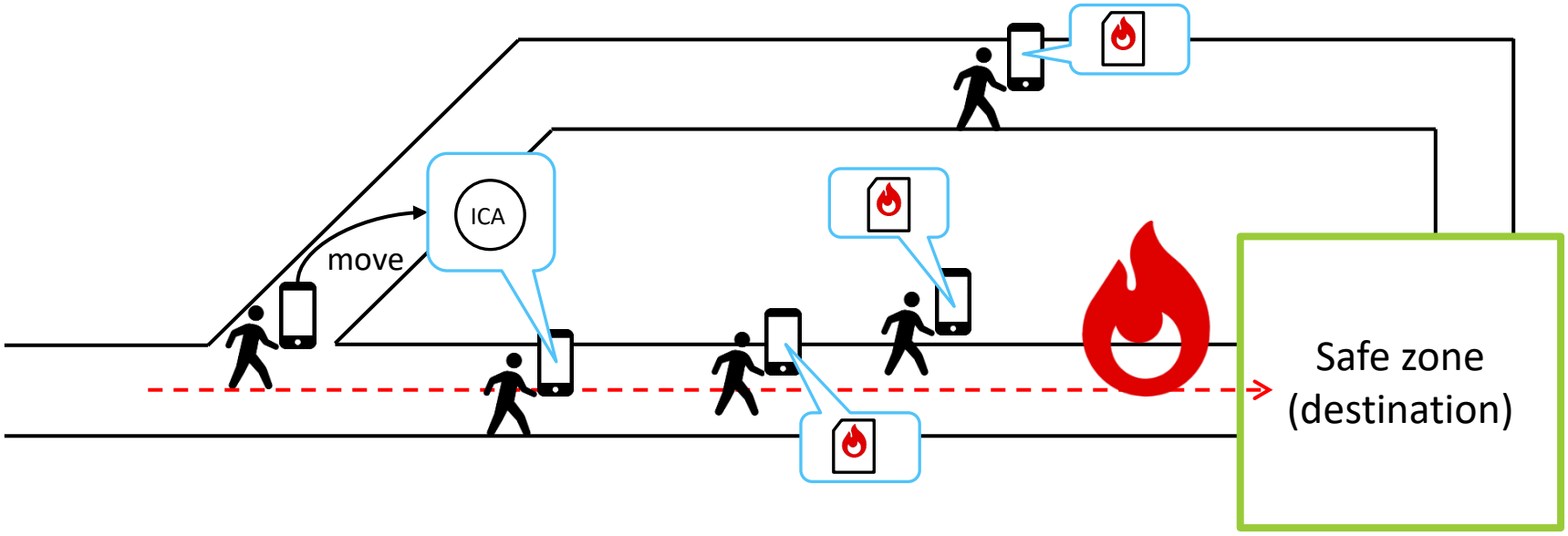
Agent System

- The IA generates the Information Collecting Agent (ICA) at regular time intervals.



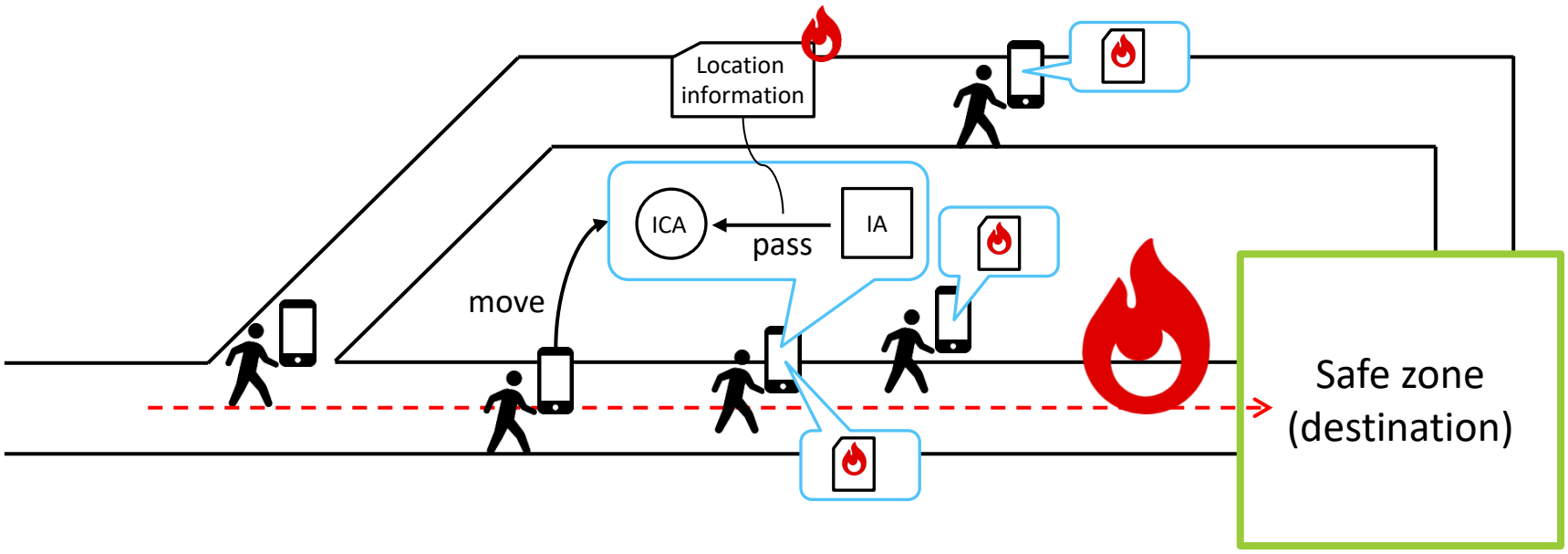
Agent System

- The ICA moves to a smartphone that on the evacuation route, and searches information of dangerous point.



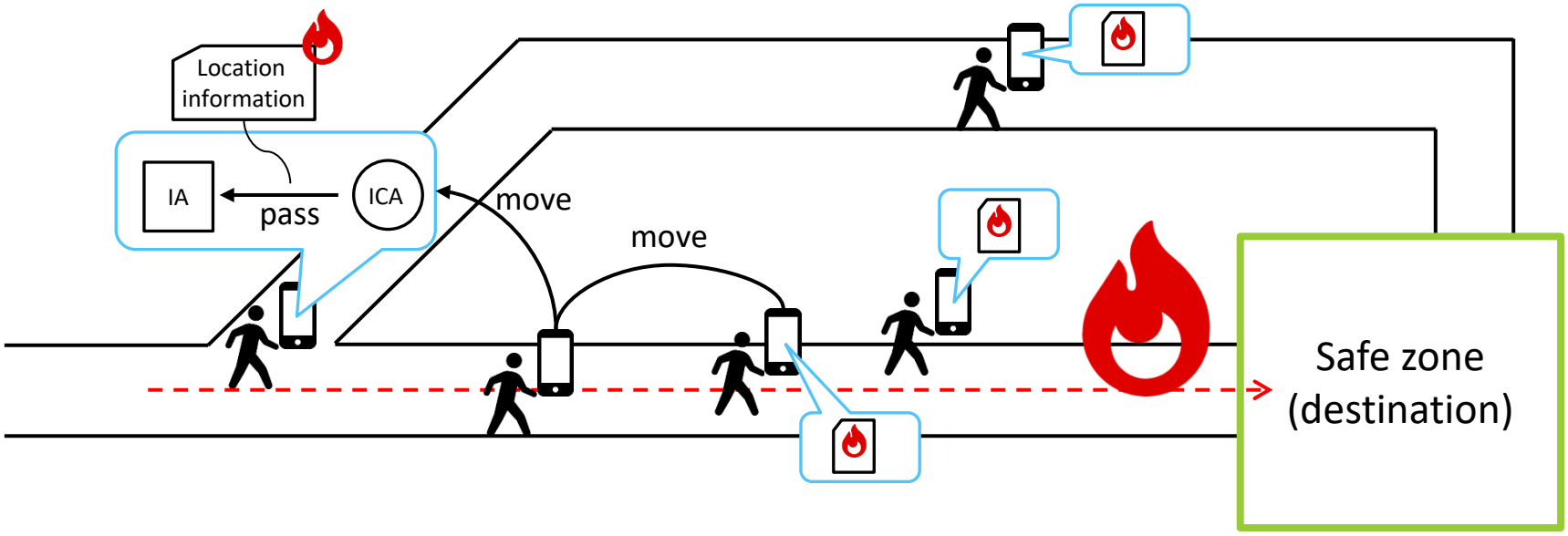
Agent System

- If the smartphone has position information of dangerous point, the ICA receives the information from the IA on the smartphone.



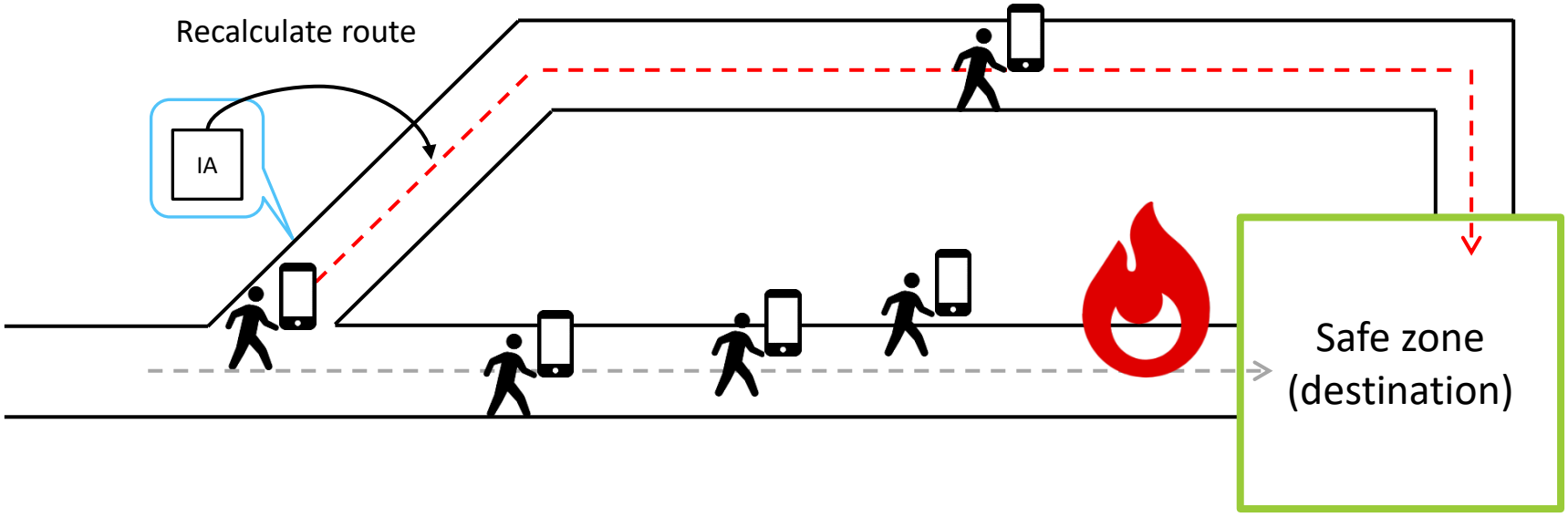
Agent System

- The ICA return to the owner's smartphone, then passes the position information to the IA.



Agent System

- The IA recalculates an evacuation route that avoiding the dangerous point.

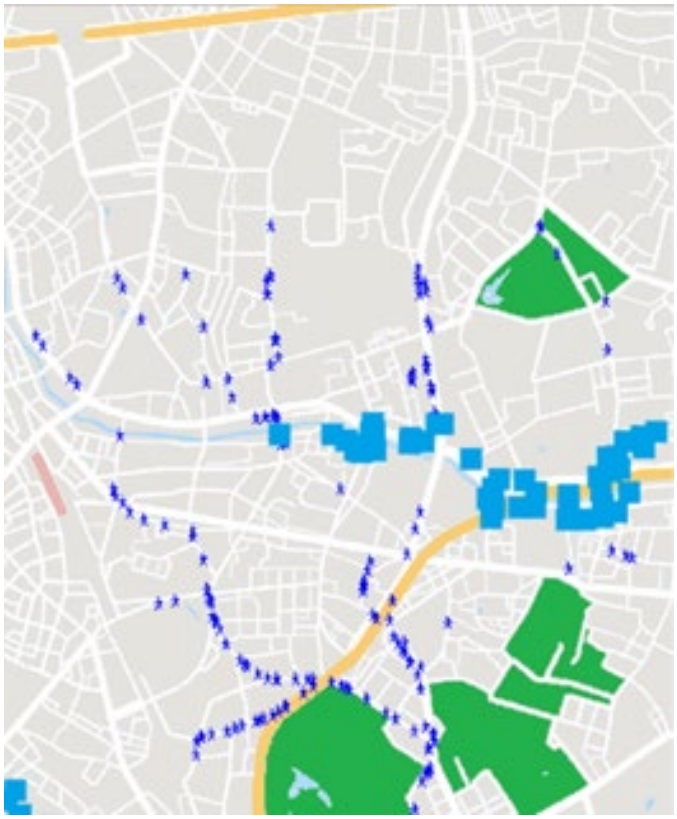


Experiment

- In order to confirm the effectivity of the proposed system, we verified by using a simulator.
- We used NS3 that is a discrete-event network simulator.

Experiment

- Simulation



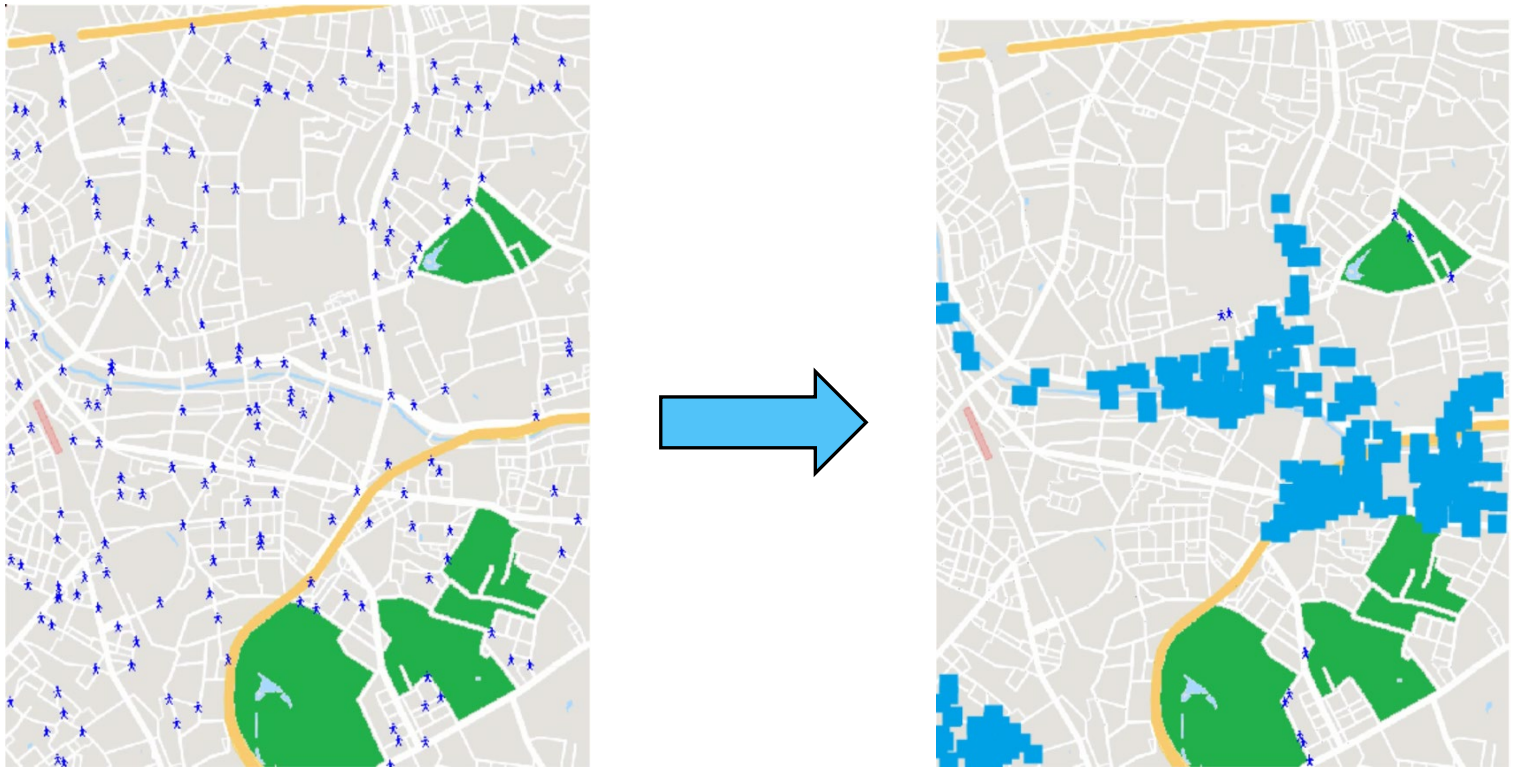
: Evacuee

: Destination
(Safe area)

: Dangerous point
(Tsunami or flood tide)

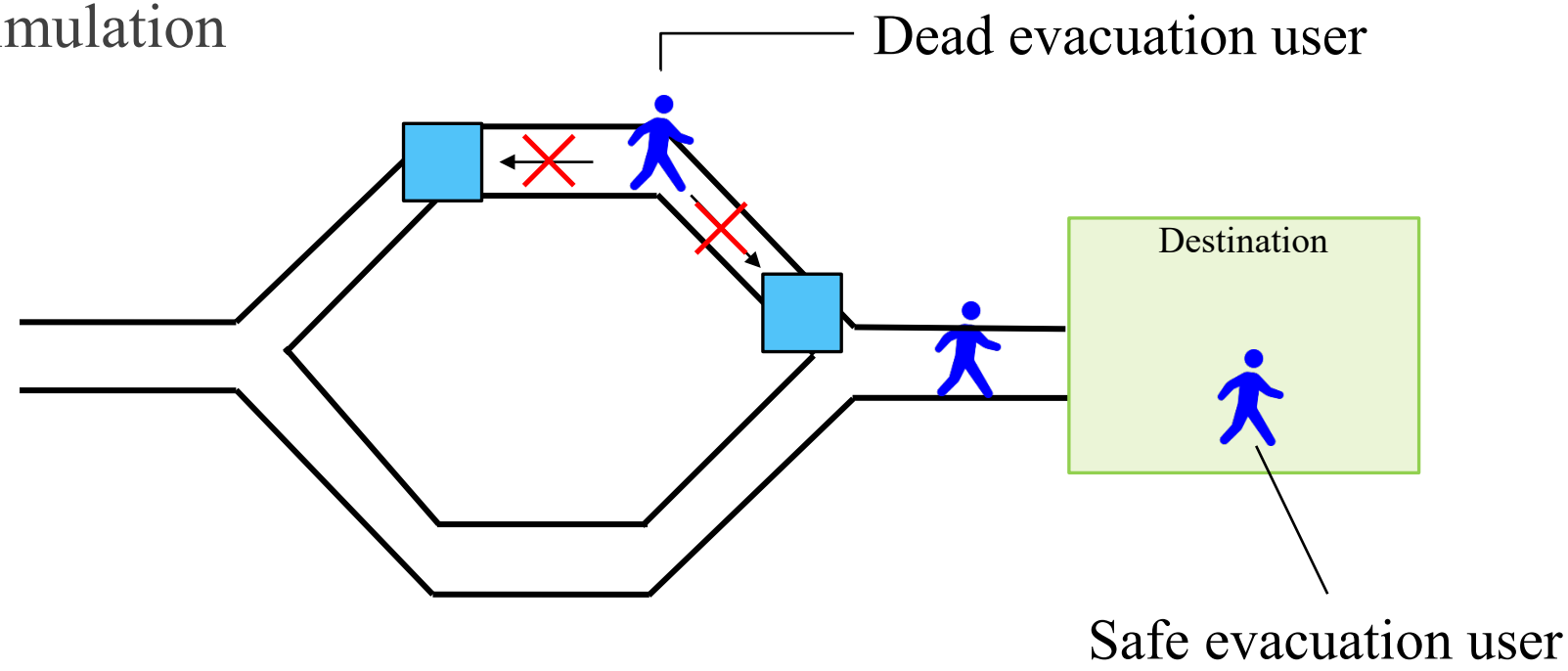
Experiment

- Simulation



Experiment

- Simulation



Experiment

- Validation items
  1. The number of the touches to the dangerous points of all evacuees.
  2. The number of the safe evacuation users and the dead evacuation users.

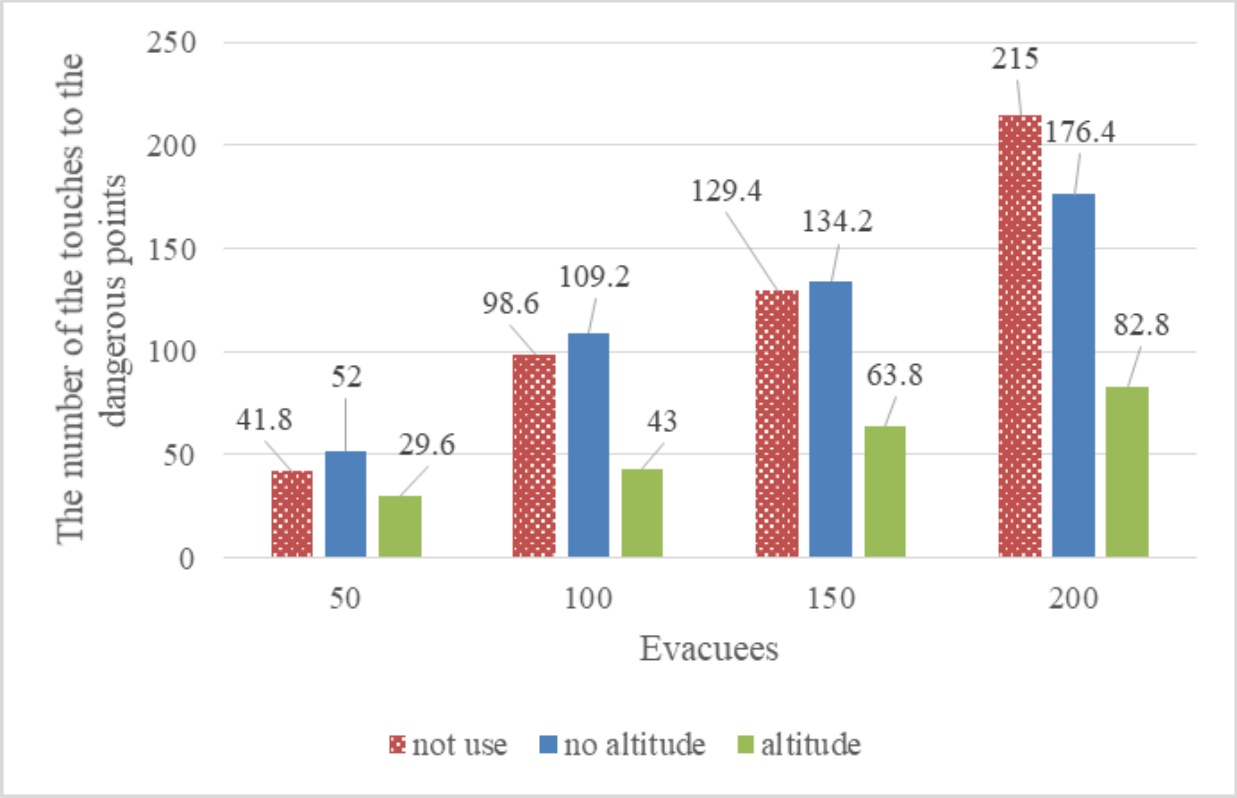
- Cases
  A) Evacuees do not use system. (Evacuees calculate a route to the destination, but dose not share information.)
  B) Evacuees use system, but do not consider altitude.
  C) Evacuees use system, and consider altitude.

Experiment

- Terms
  - The number of evacuees : 50, 100, 150, 200
  - Moving Speed of evacuee : 1 metre / seconds
  - Increasing rate of dangerous points : 1 point / 10 seconds

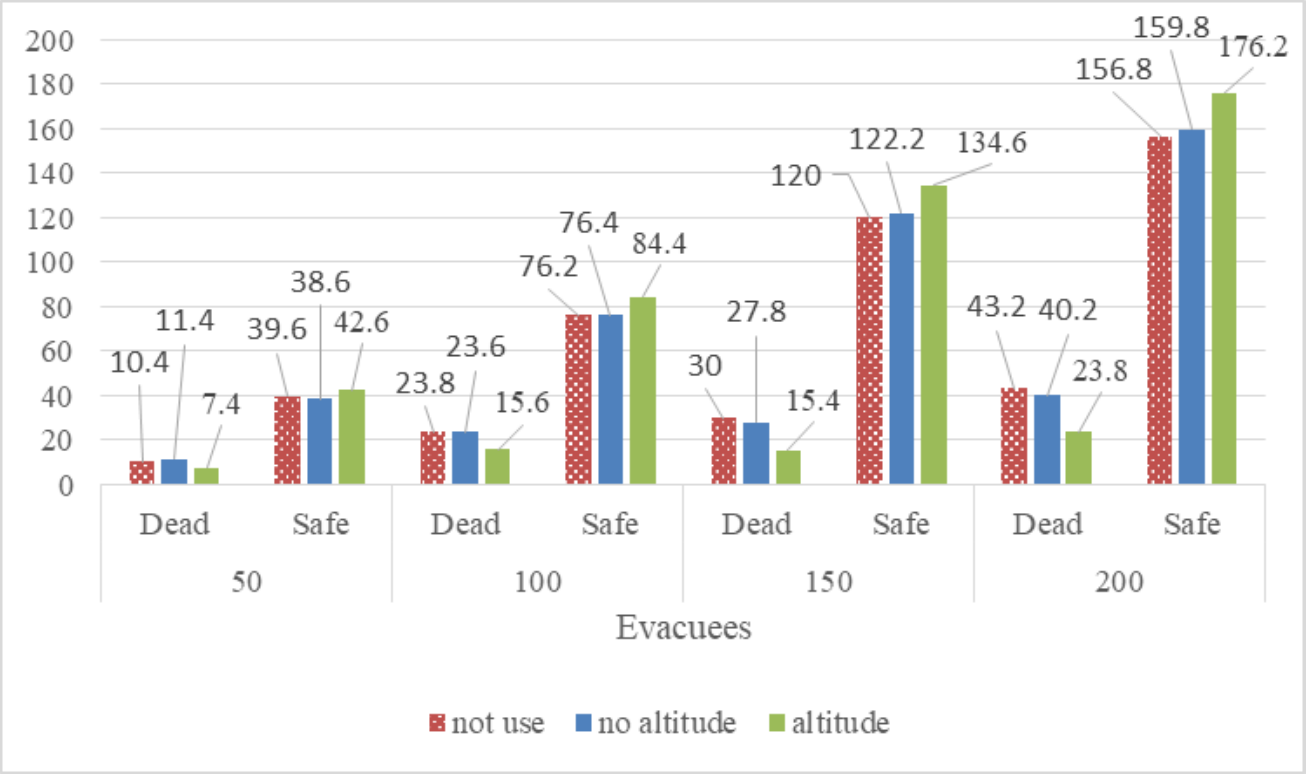
Result

- The number of the touches to the dangerous points



Result

- The number of the safe and the dead evacuation users



Conclusion

- Summary
  - We proposed an evacuation support system.
  - Evacuees can safely evacuate by choosing high altitude evacuation route when they are hit by tsunamis and flood tides.

Conclusion

- Future works
  - It is necessary to address the increase of the load in the relay smartphones.
    - The network load drastically increases in particular places such as main street.
  - We need to consider an evacuation time when choosing high altitude route.
    - Since high altitude route is not the shortest route to the safe place, the evacuation time will increase.

Thank you very much.