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Horiuchi et al.

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(54) **WARNING CONTROL APPARATUS, MOVING OBJECT, WARNING CONTROL METHOD, AND COMPUTER-READABLE STORAGE MEDIUM**

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G06T 7/20 (2017.01)
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(58) **Field of Classification Search**
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(Continued)

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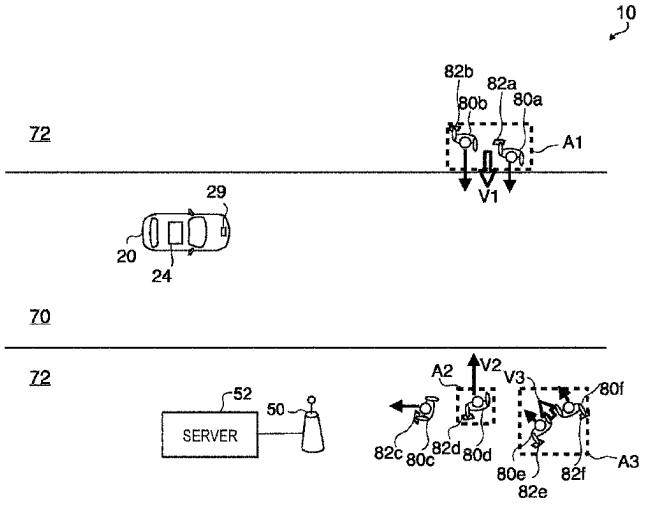
Primary Examiner — Akwasi M Sarpong
Assistant Examiner — Michael L Burleson

(57) **ABSTRACT**

Provided is a warning control apparatus comprising: an obtainment unit configured to obtain recognition information including position information and a moving direction of each of a plurality of targets present outside a moving object; a classification unit configured to classify the plurality of targets into one or more groups based on the position information and the moving direction of each of the plurality of targets; a risk level determination unit configured to determine, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches a moving object; a selection unit configured to select, based on the determined risk level, a plurality of groups to be warned; and a transmission control unit configured to control transmission of warning information including position information of the selected one or more groups.

14 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

G06T 7/70	(2017.01)
G06V 10/764	(2022.01)
G06V 40/10	(2022.01)
G08G 1/005	(2006.01)

(52) **U.S. Cl.**
CPC ***G06V 40/10*** (2022.01); ***G08G 1/005*** (2013.01); *G06T 2207/30196* (2013.01); *G06T 2207/30252* (2013.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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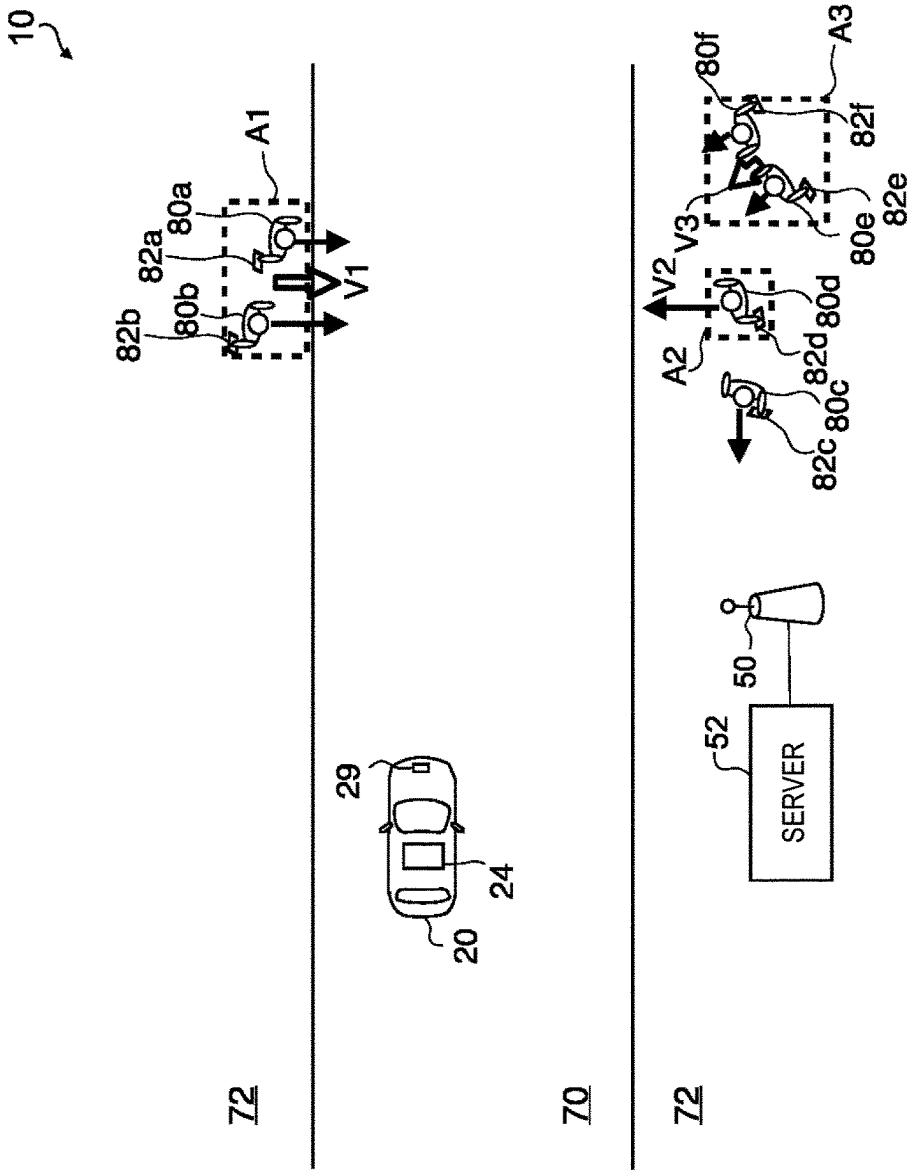
10
A1
80a
82a
80b
82b
V1
72
29
24
20
70
72
A3
80f
82f
82e
80e
V3
V2
A2
80d
82d
80c
82c
50
52
SERVER

FIG. 1

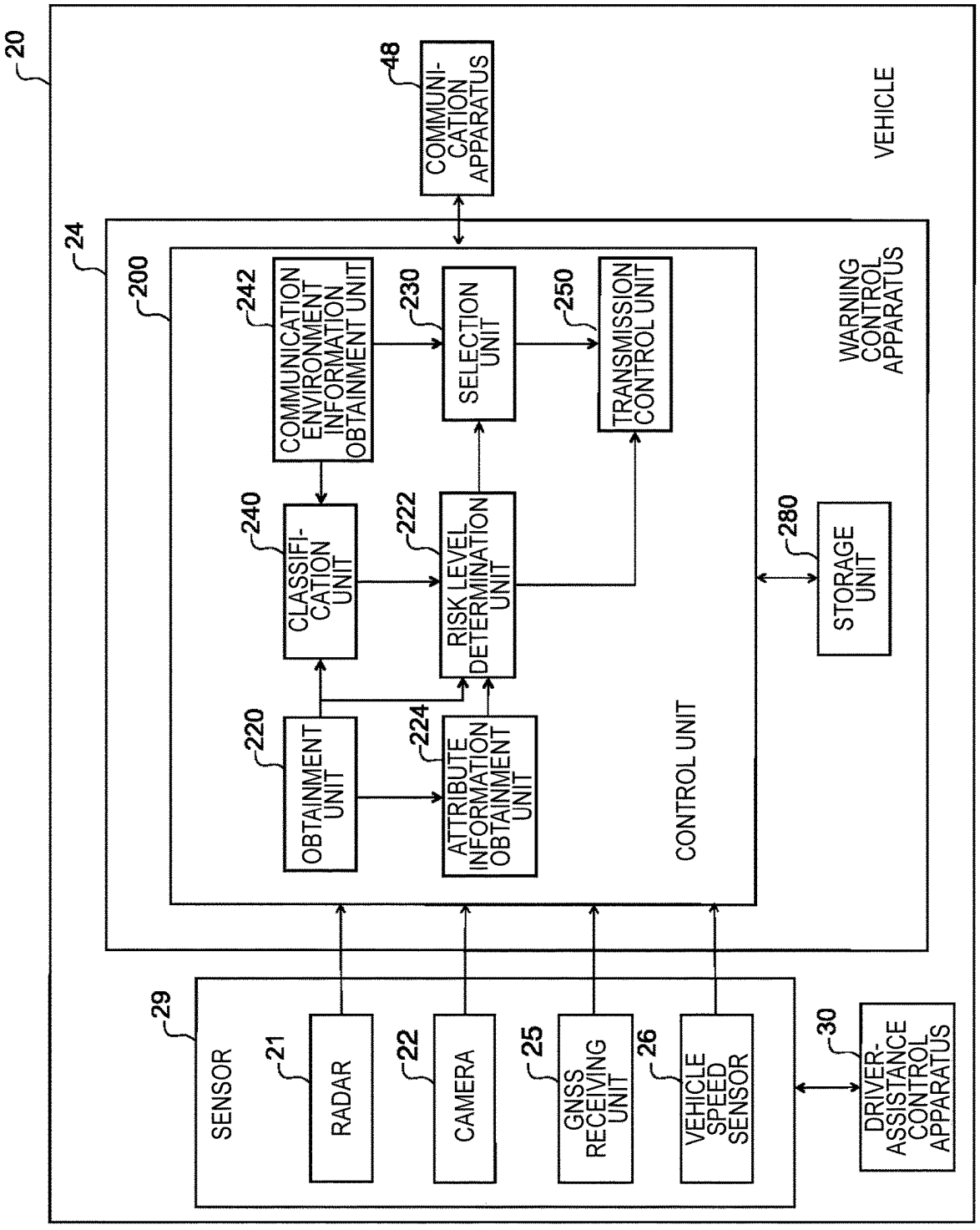
20
VEHICLE
48
COMMUNI-CATION APPARATUS
24
WARNING CONTROL APPARATUS
200
CONTROL UNIT
242
COMMUNICATION ENVIRONMENT INFORMATION OBTAINMENT UNIT
230
SELECTION UNIT
250
TRANSMISSION CONTROL UNIT
240
CLASSIFI-CATION UNIT
222
RISK LEVEL DETERMINATION UNIT
280
STORAGE UNIT
220
OBTAINMENT UNIT
224
ATTRIBUTE INFORMATION OBTAINMENT UNIT
29
SENSOR
21
RADAR
22
CAMERA
25
GNSS RECEIVING UNIT
26
VEHICLE SPEED SENSOR
30
DRIVER-ASSISTANCE CONTROL APPARATUS

FIG.2

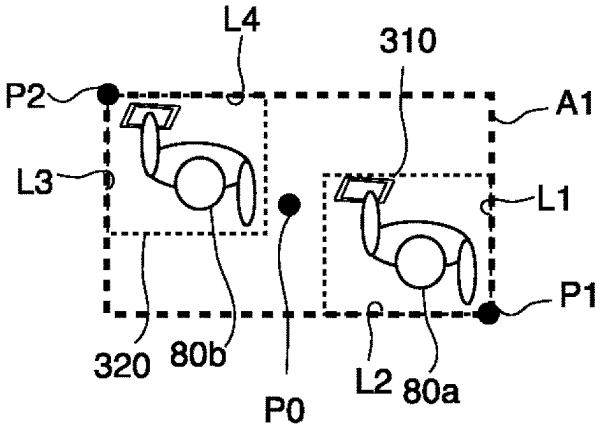

FIG.3

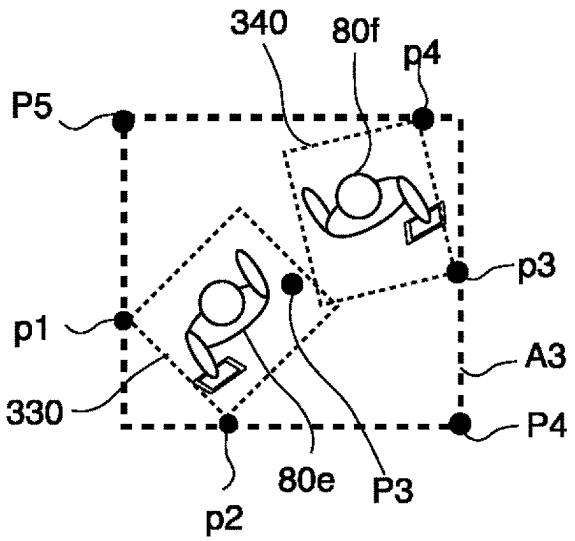

FIG.4

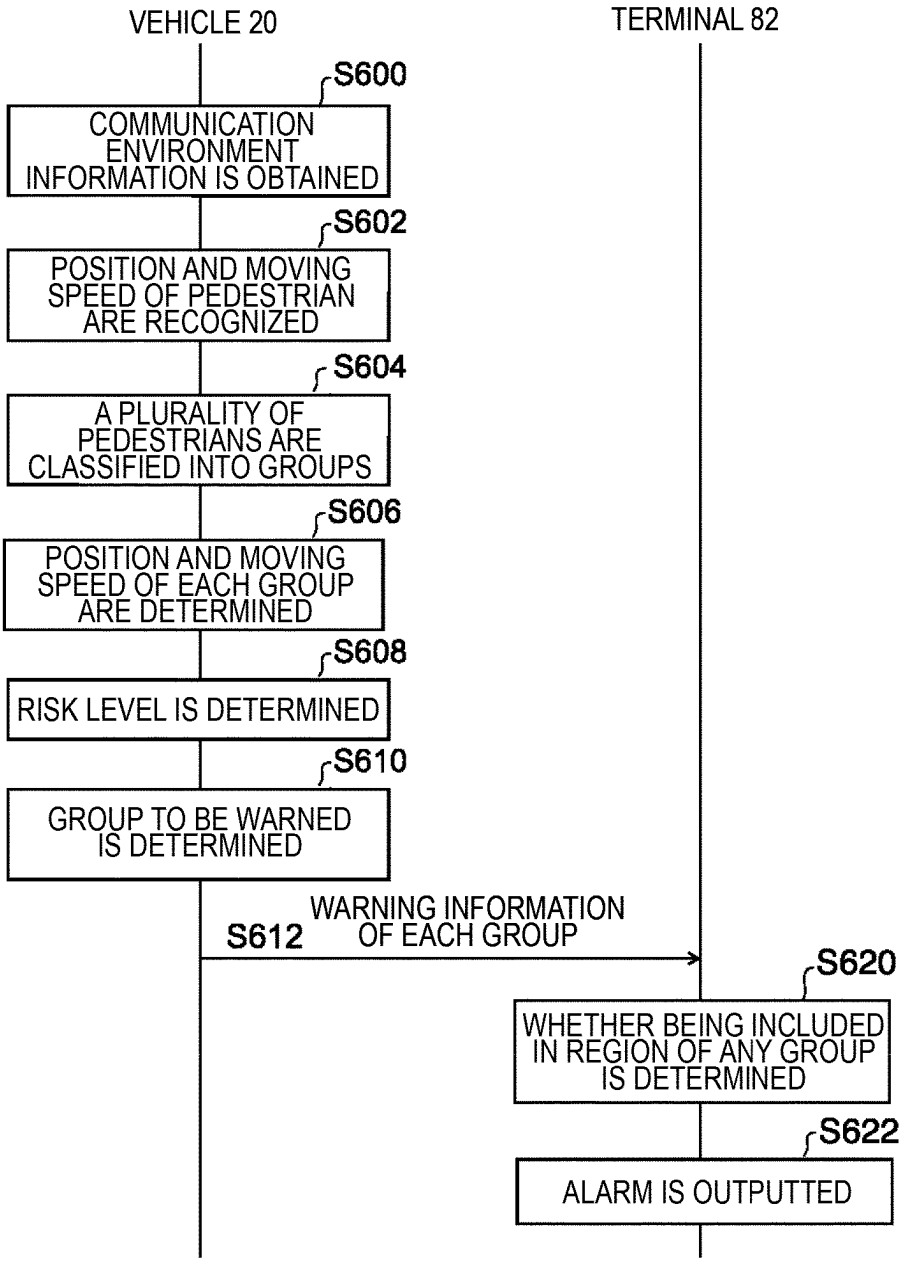
VEHICLE 20
TERMINAL 82
S600
COMMUNICATION ENVIRONMENT INFORMATION IS OBTAINED
S602
POSITION AND MOVING SPEED OF PEDESTRIAN ARE RECOGNIZED
S604
A PLURALITY OF PEDESTRIANS ARE CLASSIFIED INTO GROUPS
S606
POSITION AND MOVING SPEED OF EACH GROUP ARE DETERMINED
S608
RISK LEVEL IS DETERMINED
S610
GROUP TO BE WARNED IS DETERMINED
S612
WARNING INFORMATION OF EACH GROUP
S620
WHETHER BEING INCLUDED IN REGION OF ANY GROUP IS DETERMINED
S622
ALARM IS OUTPUTTED

FIG.5

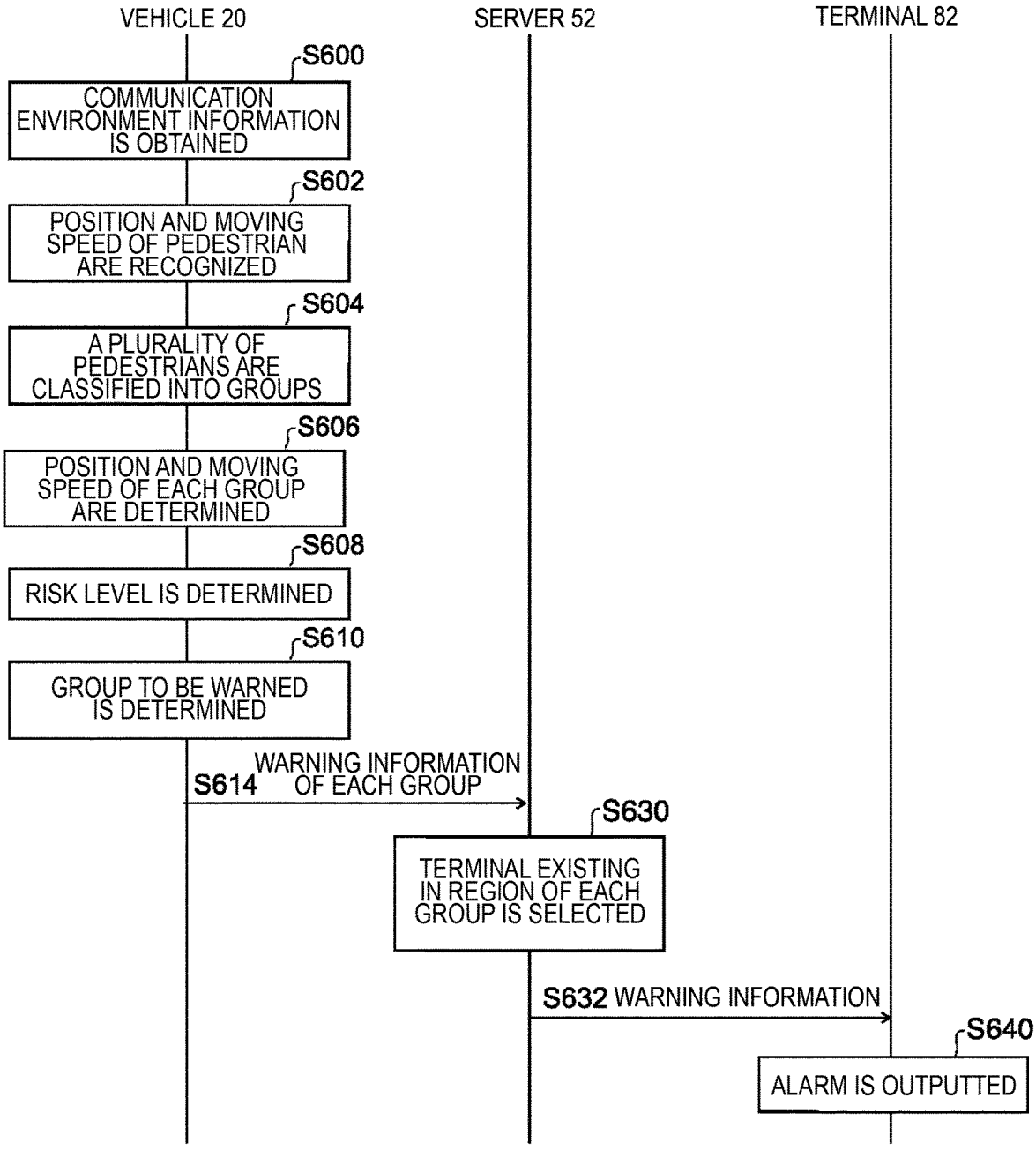
VEHICLE 20
SERVER 52
TERMINAL 82
S600
COMMUNICATION ENVIRONMENT INFORMATION IS OBTAINED
S602
POSITION AND MOVING SPEED OF PEDESTRIAN ARE RECOGNIZED
S604
A PLURALITY OF PEDESTRIANS ARE CLASSIFIED INTO GROUPS
S606
POSITION AND MOVING SPEED OF EACH GROUP ARE DETERMINED
S608
RISK LEVEL IS DETERMINED
S610
GROUP TO BE WARNED IS DETERMINED
S614 WARNING INFORMATION OF EACH GROUP
S630
TERMINAL EXISTING IN REGION OF EACH GROUP IS SELECTED
S632 WARNING INFORMATION
S640
ALARM IS OUTPUTTED

FIG.6

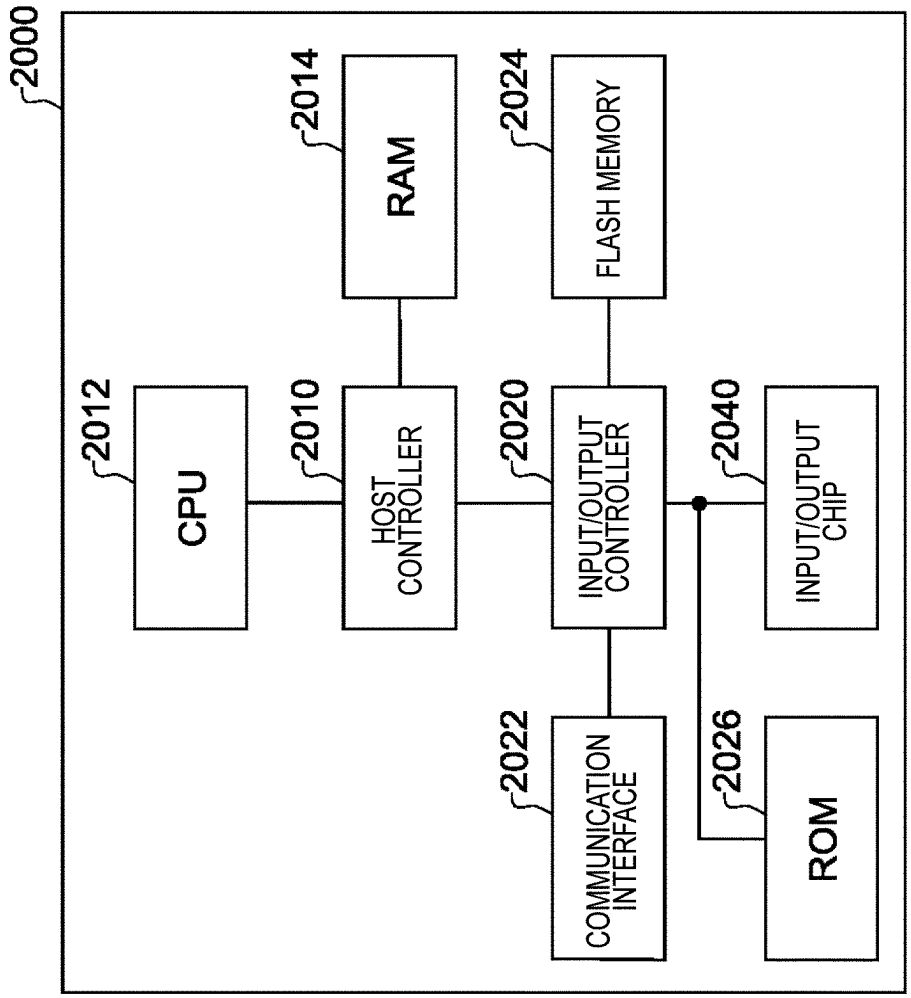
2000
2014
RAM
2024
FLASH MEMORY
2012
CPU
2010
HOST CONTROLLER
2020
INPUT/OUTPUT CONTROLLER
2040
INPUT/OUTPUT CHIP
2022
COMMUNICATION INTERFACE
2026
ROM

FIG. 7

WARNING CONTROL APPARATUS, MOVING OBJECT, WARNING CONTROL METHOD, AND COMPUTER-READABLE STORAGE MEDIUM

The contents of the following Japanese patent application(s) are incorporated herein by reference:
NO. 2021-101644 filed on Jun. 18, 2021.

BACKGROUND

1. Technical Field

The present invention relates to a warning control apparatus, a moving object, a warning control method, and a computer-readable storage medium.

2. Related Art

Patent Document 1 describes that pedestrians on a pedestrian crossing are grouped in accordance with a travelling direction of each pedestrian to predict times required only for a first pedestrian and a last pedestrian in the group to reach a lane side. Patent Document 2 describes, regarding a pedestrian terminal apparatus, that it is determined whether a pedestrian carrying the pedestrian terminal apparatus is located within a pedestrian group based on position information of the pedestrian terminal apparatus and position information of another pedestrian terminal apparatus included in notice information and that pedestrian-to-vehicle communication is stopped if the pedestrian is located within the pedestrian group.

PRIOR ART DOCUMENT

Patent Document 1: Japanese Patent Application Publication No. 2001-126193
Patent Document 2: Japanese Patent Application Publication No. 2017-111741

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically shows a usage scene of a warning system **10**.

FIG. **2** shows a system configuration of a vehicle **20**.

FIG. **3** illustrates one example of position information of a group included in warning information transmitted by a transmission control unit **250**.

FIG. **4** illustrates another example of the position information of the group included in the warning information transmitted by the transmission control unit **250**.

FIG. **5** roughly shows a processing flow related to a warning control method executed by a vehicle **20** and a terminal **82**.

FIG. **6** roughly shows another processing flow related to the warning control method executed by the vehicle **20**, a server **52**, and the terminal **82**.

FIG. **7** shows an example of a computer **2000**.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, the present invention will be described through embodiments of the invention, but the following embodiments do not limit the claimed invention. Moreover, not all combinations of features described in the embodiments are necessary to solutions of the invention.

FIG. **1** schematically shows a usage scene of a warning system **10**. The warning system **10** includes a vehicle **20**, a base station **50** and a server **52**, as well as a terminal **82***a*, a terminal **82***b*, a terminal **82***c*, a terminal **82***d*, a terminal **82***e*, and a terminal **82***f*.

The terminal **82***a* is carried by a pedestrian **80***a*. The terminal **82***b* is carried by a pedestrian **80***b*. The terminal **82***c* is carried by a pedestrian **80***c*. The terminal **82***d* is carried by a pedestrian **80***d*. The terminal **82***e* is carried by a pedestrian **80***e*. The terminal **82***f* is carried by a pedestrian **80***f* The terminal **82** performs mobile communications through the base station **50**. The terminal **82***a*, the terminal **82***b*, the terminal **82***c*, the terminal **82***d*, the terminal **82***e*, and the terminal **82***f* receive a variety of services through the server **52** connected to the base station **50**. The server **52** may include, for example, an edge computing server such as a MEC server. It should be noted that the terminal **82***a*, the terminal **82***b*, the terminal **82***c*, the terminal **82***d*, the terminal **82***e*, and the terminal **82***f* may be referred to collectively as "terminals **82**". The pedestrian **80***a*, the pedestrian **80***b*, the pedestrian **80***c*, the pedestrian **80***d*, the pedestrian **80***e*, and the pedestrian **80***f* may be referred to collectively as "pedestrian(s) **80**". The vehicle **20** is one example of a "moving object".

In the warning system **10**, the vehicle **20** transmits warning information for causing the terminal **82** to output warning information when there is a pedestrian **80** at risk of approaching the vehicle **20**. When receiving the warning information, the terminal **82** gives warning to the pedestrian **80** with warning display, sound, vibration, or the like. This gives notice to the pedestrian **80** that the vehicle **20** is approaching.

The terminal **82** may be a mobile terminal such as a mobile phone or a smartphone. The terminal **82** includes a positioning function. For example, the terminal **82** receives a radio wave transmitted from a Global Navigation Satellite System (GNSS) satellite, and determines a current position of the terminal **82** based on the radio wave transmitted from the GNSS satellite. The terminal **82** periodically updates the current position of the terminal **82** by periodically performing positioning.

In this embodiment, a case will be mainly described where a target at risk of approaching the vehicle **20** is a "pedestrian". However, the target at risk of approaching the vehicle **20** may be another moving object or vehicle. In this case, a "terminal" may be a communication apparatus such as a Telematics Control Unit (TCU) included in another vehicle.

The vehicle **20** includes a sensor **29** and a warning control apparatus **24**. The sensor **29** includes a camera and a radar. The sensor **29** obtains information on a front area of the vehicle **20**. For example, the sensor **29** obtains an image of and ranging information on the front area of the vehicle **20**. The warning control apparatus **24** recognizes the image obtained by a camera included in the sensor **29**, to detect the pedestrian **80**. Moreover, the warning control apparatus **24** detects a current position of the pedestrian **80** based on the ranging information obtained by the radar and a current position of the vehicle **20**. The warning control apparatus **24** identifies a moving direction of the pedestrian **80** or the like based on an orientation of the pedestrian **80** or the like. The warning control apparatus **24** identifies, based on the current position and the moving direction of the pedestrian **80**, the pedestrian **80** at risk of approaching the vehicle **20**, in particular, the pedestrian **80** who may move onto a scheduled driving route of the vehicle **20**.

For example, in a situation shown in FIG. **1**, the vehicle **20** is driving in a roadway **70**. The roadway **70** is provided with walkways **72** on its both sides. The warning control apparatus **24** recognizes, from information detected by the sensor **29**, a position of the pedestrian **80** walking in the walkway **72**. The warning control apparatus **24** may identify a moving speed of the pedestrian **80** based on a temporal change in the position of the pedestrian **80**, a temporal change in a distance from the vehicle **20** to the pedestrian **80**, and a body orientation of the pedestrian **80**, or the like. It should be noted that an arrow correlated with the pedestrian **80** in FIG. **1** roughly indicates the moving speed of the pedestrian **80**.

The warning control apparatus **24** groups the pedestrians **80** based on the recognized positions and moving speeds of the pedestrians **80**. For example, the warning control apparatus **24** classifies, into a same group, the pedestrians **80** located closer to one another and having a higher coincidence level of moving speed. Specifically, the warning control apparatus **24** determines that the pedestrian **80***a* and the pedestrian **80***b* are located close to each other and have a high coincidence level of moving speed, to classify the pedestrian **80***a* and the pedestrian **80***b* into one group. The warning control apparatus **24** determines that the pedestrian **80***e* and the pedestrian **80***f* are located close to each other and have a high coincidence level of moving speed in a direction towards the roadway **70**, to classify the pedestrian **80***e* and the pedestrian **80***f* into one group. The warning control apparatus **24** determines that the pedestrian **80***c* and the pedestrian **80***d* have a low coincidence level of moving speed although being located close to each other, to classify the pedestrian **80***c* and the pedestrian **80***d* into separate groups.

Based on the positions and the moving directions of the pedestrians **80** classified into the same group, the warning control apparatus **24** determines a risk level of approaching the vehicle **20** for each group. For example, the warning control apparatus **24** sets an average position of the positions of the pedestrian **80***a* and the pedestrian **80***b* as a position of the group, while setting an average speed of the moving speeds of the pedestrian **80***a* and the pedestrian **80***b* as a moving speed V**1** of the group. From the moving speed of the group including the pedestrian **80***a* and the pedestrian **80***b*, the warning control apparatus **24** determines, when the group is moving in the direction towards the roadway **70** and keeps moving in the same direction, that the group may enter the roadway **70** before the vehicle **20** passes by. Therefore, the warning control apparatus **24** determines that the group including the pedestrian **80***a* and the pedestrian **80***b* has a high risk level of approaching the vehicle **20** (the risk level is "high").

For the group including the pedestrian **80***e* and the pedestrian **80***f*, the warning control apparatus **24** sets an average position of the positions of the pedestrian **80***e* and the pedestrian **80***f* as a position of the group, while setting an average speed of the moving speeds of the pedestrian **80***e* and the pedestrian **80***f* as a moving speed V**3** of the group. The warning control apparatus **24** determines, from the moving speed of the group including the pedestrian **80***e* and the pedestrian **80***f*, that the vehicle **20** is likely to pass by before the group enters the roadway **70** although the group is moving in the direction towards the roadway **70**. Therefore, the warning control apparatus **24** determines that the group including the pedestrian **80***e* and the pedestrian **80***f* has a moderate risk level of approaching the vehicle **20** (the risk level is "moderate").

For the group of the pedestrian **80***c*, the warning control apparatus **24** sets the position of the pedestrian **80***c* as a position of the group, while setting the moving speed of the pedestrian **80***c* as a moving speed of the group. The warning control apparatus **24** determines that the group of the pedestrian **80***c* is moving in the walkway **72** in parallel with the roadway **70**, and determines that the group of the pedestrian **80***c* has a low risk level of approaching the vehicle **20** (the risk level is "low"). For the group of the pedestrian **80***d*, the warning control apparatus **24** sets the position of the pedestrian **80***d* as a position of the group, while setting the moving speed of the pedestrian **80***d* as a moving speed of the group. The warning control apparatus **24** determines, when the group of the pedestrian **80***d* is moving in the direction towards the roadway **70** and keeps moving in the same direction, that the group may enter the roadway **70** before the vehicle **20** passes by. Therefore, the warning control apparatus **24** determines that the group of the pedestrian **80***d* has a high risk level of approaching the vehicle **20** (the risk level is "high").

The warning control apparatus **24** selects, as a target to be transmitted the warning information, a group determined to have a risk level of "high" or "moderate". The warning control apparatus **24** generates the warning information including a position of each of the three groups selected as the target to be transmitted the warning information. For example, the warning control apparatus **24** sets an area A**1** including the positions of the pedestrian **80***a* and the pedestrian **80***b*, an area A**2** including the position of the pedestrian **80***d*, and an area A**3** including the positions of the pedestrian **80***e* and the pedestrian **80***f*. The warning control apparatus **24** generates first warning information including latitude/longitude information indicating a position of the area A**1**, second warning information including latitude/longitude information indicating a position of the area A**2**, and third warning information including latitude/longitude information indicating a position of the area A**3**. The warning control apparatus **24** transmits the first warning information, the second warning information, and the third warning information. For example, the warning control apparatus **24** transmits the first warning information, the second warning information, and the third warning information by broadcasting.

The terminal **82***a* identifies the area A**1** from the latitude/longitude information included in the received first warning information, and determines that a current position of the terminal **82***a* is included in the area A**1**. Accordingly, the terminal **82***a* outputs an alarm with an HMI function of the terminal **82***a*. Similarly, the terminal **82***b* determines that a current position of the terminal **82***b* is included in the area A**1** identified from the received first warning information, and outputs an alarm with an HMI function of the terminal **82***b*. Moreover, the terminal **82***d* determines that a current position of the terminal **82***d* is included in the area A**2** identified from the received second warning information, and outputs an alarm with an HMI function of the terminal **82***d*. Moreover, the terminal **82***e* and the terminal **82***f* respectively determine that current positions of the terminals **82***e* and **82***f* are included in the area A**3** identified from the received third warning information, and output alarms with HMI functions of the terminals **82***e* and **82***f*.

On the other hand, the terminal **82***c* determines that a position of the terminal **82***c* is not included in any of the area A**1**, the area A**2**, and the area A**3** indicated by the received first warning information, second warning information, and third warning information. As a result, the terminal **82***c* determines that there is no need to output an alarm to the

pedestrian **80***c*. Therefore, the terminal **82***b* discards the warning information without outputting an alarm.

Thus, in the warning system **10**, the warning control apparatus **24** can classify the pedestrian **80***a*, the pedestrian **80***b*, the pedestrian **80***d*, the pedestrian **80***e*, and the pedestrian **80***f* into the three groups to transmit the warning information to the three groups, instead of transmitting the warning information to each of the pedestrian **80***a*, the pedestrian **80***b*, the pedestrian **80***d*, the pedestrian **80***e*, and the pedestrian **80***f*. Therefore, it is possible to reduce a communication resource used for transmission of the warning information. This can reduce a possibility that the warning information can be no longer transmitted, even in a situation where there are many pedestrians **80** to be transmitted the warning information.

FIG. **2** shows a system configuration of the vehicle **20**. The vehicle **20** includes a sensor **29**, a warning control apparatus **24**, and a driver-assistance control apparatus **30**.

The sensor **29** includes a radar **21**, a camera **22**, a GNSS receiving unit **25**, and a vehicle speed sensor **26**. The radar **21** may be a LiDAR, a millimeter-wave radar, or the like. The GNSS receiving unit **25** receives a radio wave transmitted from a Global Navigation Satellite System (GNSS) satellite. The GNSS receiving unit **25** generates information indicating the current position of the vehicle **20** based on a signal received from the GNSS satellite. The camera **22** captures an image of a surrounding area of the vehicle **20** to generate image information. For example, the camera **22** captures an image in a travelling direction of the vehicle **20** to generate the image information. The camera **22** is one example of an image capturing unit mounted on the vehicle **20**. The vehicle speed sensor **26** detects a vehicle speed of the vehicle **20**. It should be noted that sensor **29** may include a position sensor such as an odometer, or an Inertial Measurement Unit (IMU) such as an acceleration sensor or an attitude sensor.

The driver-assistance control apparatus **30** uses the information detected by the sensor **29**, to perform driver-assistance of the vehicle **20**. The driver-assistance control apparatus **30** may be realized by an Electronic Control Unit (ECU) having a function of an Advanced Driver-Assistance Systems (ADAS).

The warning control apparatus **24** includes a control unit **200**, a storage unit **280**, and a communication apparatus **48**. The control unit **200** is realized by, for example, an arithmetic processing unit including a processor. The storage unit **280** is realized including a non-volatile storage medium. The control unit **200** uses the information stored in the storage unit **280** to perform processing. The communication apparatus **48** is responsible for direct communication with the terminal **82**. The control unit **200** may be realized by the ECU including a microcomputer provided with a CPU, a ROM, a RAM, an I/O, a bus, and the like.

The control unit **200** includes an obtainment unit **220**, a risk level determination unit **222**, a selection unit **230**, a classification unit **240**, an attribute information obtainment unit **224**, a communication environment information obtainment unit **242**, and a transmission control unit **250**. It should be noted that a configuration may be adopted in which the control unit **200** does not have some functions in functional blocks shown in FIG. **2**. For example, a configuration may be adopted in which only some functions are implemented in the control unit **200** while the other functions are implemented as functions of the sensor **29** or another circuit.

The obtainment unit **220** obtains recognition information including position information and a moving direction of each of a plurality of targets present outside the vehicle **20**. For example, the obtainment unit **220** obtains the recognition information by performing image recognition of an image captured by the camera **22**. Specifically, the obtainment unit **220** obtains the recognition information including the position information and the moving direction by recognizing the position information and the moving direction through the image recognition of the image captured by the camera **22** mounted on the vehicle **20**. Specifically, the obtainment unit **220** extracts, by performing the image recognition of the image captured by the camera **22**, the pedestrian **80** at risk of approaching the vehicle **20**. Moreover, the obtainment unit **220** may obtain distance information to the pedestrian **80** with the radar **21**. The obtainment unit **220** may obtain the distance information to the pedestrian **80** based on the image captured by the camera **22**. The obtainment unit **220** calculates, based on the position information of the vehicle **20** and the distance information to the pedestrian **80**, a position of a target at risk of approaching the vehicle **20**. The obtainment unit **220** may recognize the moving direction of the pedestrian **80** based on the body orientation of the pedestrian **80**.

The classification unit **240** classifies the plurality of targets into one or more groups based on position information and a moving direction of each of the plurality of targets. For example, the classification unit **240** may classify the targets having higher coincidence levels of position and moving direction than predetermined values into the same group, while classifying the targets having lower coincidence levels of position and moving direction than the predetermined values into different groups. The risk level determination unit **222** determines, based on position information and moving directions of the groups, a risk level at which each of the one or more groups approaches the vehicle **20**. The selection unit **230** selects, based on the risk level determined by the risk level determination unit **222**, a plurality of groups to be warned. The transmission control unit **250** controls transmission of warning information including position information of the one or more groups selected by the selection unit **230**.

The recognition information may include the position information, the moving direction, and a moving speed of each of the plurality of targets present outside the vehicle **20**. The classification unit **240** may classify the plurality of targets into one or more groups based on the position information, the moving direction, and the moving speed of each of the plurality of targets. For example, the obtainment unit **220** may recognize the moving speed of the target based on a temporal change in a position of the target. The obtainment unit **220** may recognize the moving speed of the target by obtaining a relative speed between the recognized moving speed of the target and the moving speed of the vehicle **20** detected by the vehicle speed sensor **26**. The obtainment unit **220** may recognize, based on a temporal change in a distance to a recognized target, the moving speed of the target by obtaining the relative speed between the recognized target and the vehicle **20**.

The transmission control unit **250** may control the transmission of the warning information including central coordinates of the position information of the plurality of targets classified into each group. The transmission control unit **250** may control the transmission of the warning information including a plurality of pieces of coordinate information indicating an area including the position information of the plurality of targets classified into each group.

It should be noted that the transmission control unit **250** controls the transmission of the warning information performed without specifying a destination. For example, the

transmission control unit **250** may cause the communication apparatus **48** to transmit the warning information by broadcasting via direct communication. It should be noted that the transmission control unit **250** may transmit the warning information to the server **52** that manages position information of a plurality of terminals **82**, and control the transmission of the warning information to the terminal **82** through the server **52**. It should be noted that the transmission control unit **250** may cause the communication apparatus **48** to transmit the warning information via directional communication. For example, the communication apparatus **48** has a directional antenna, and the transmission control unit **250** may cause the communication apparatus **48** to transmit the warning information towards a position of the recognized target.

The communication environment information obtainment unit **220** obtains information indicating a communication environment. The classification unit **240** determines, based on the communication environment obtained by the communication environment information obtainment unit **220**, a number of at least one group into which the plurality of targets are classified. For example, the communication environment information obtainment unit **220** may obtain information indicating a congestion level of communication environment. The classification unit **240** may reduce the number of groups into which the plurality of targets are classified as the congestion level obtained by the communication environment information obtainment unit **220** is higher. The information indicating the congestion level of communication environment may be delay time information of communication, communication speed information, packet loss rate, or the like.

When the targets are persons, the attribute information obtainment unit **224** obtains information indicating an age of each of the plurality of targets. When at least one of targets classified into each group has an age included in a predetermined age group, the risk level determination unit **222** determines the risk level to be higher than when none of targets classified into each group has an age included in the predetermined age group. For example, the obtainment unit **220** recognizes whether the pedestrian **80** is a child by performing image recognition of the image captured by the camera **22**. The attribute information obtainment unit **224** obtains from the obtainment unit **220** a recognition result indicating whether the pedestrian is a child, and when the attribute information obtainment unit **224** obtains the recognition result indicating that the pedestrian is a child, the risk level determination unit **222** determines the risk level to be high.

FIG. **3** illustrates one example of position information of a group included in warning information transmitted by the transmission control unit **250**. With reference to FIG. **3**, described will be position information of the area A**1** of the group including the pedestrian **80***a* and the pedestrian **80***b*.

The area **310** is a rectangular area where the recognized pedestrian **80***a* may be present. The area **320** is a rectangular area where the recognized pedestrian **80***b* may be present. The area **310** and the area **320** may each have a predetermined size occupied by a person. Orientations of the area **310** and the area **310** may each be set according to an orientation of the person. The area A**1** is surrounded by two sides with portions corresponding to two sides L**1** and L**2** that show an outline of the area **310** and two sides with portions corresponding to two sides L**3** and L**4** that show an outline of the area **320**.

The position information of the group included in the warning information may include information indicating coordinates of a central point P**0** of the area A**1**. The position information of the group included in the warning information may include information indicating latitude/longitude coordinates of the central point P**0** of the area A**1** and a size of the area A**1**. The position information of the group included in the warning information may include information indicating the latitude/longitude coordinates of the central point P**0** of the area A**1** and lengths of two sides of an outline of the area A**1**. The position information of the group included in the warning information may include information indicating latitude/longitude coordinates of two diagonal vertices P**1** and P**2** of the area A**1**.

FIG. **4** illustrates another example of the position information of the group included in the warning information transmitted by the transmission control unit **250**. With reference to FIG. **4**, described will be position information of the area A**3** of the group including the pedestrian **80***e* and the pedestrian **80***f*.

The area **330** is a rectangular area where the recognized pedestrian **80***e* may be present. The area **340** is a rectangular area where the recognized pedestrian **80***f* may be present. The area **330** and the area **340** may each have a predetermined size occupied by a person. Orientations of the area **330** and the area **340** may each be set according to an orientation of the person. The area A**3** is surrounded by two sides respectively including two vertices p**1** and p**2** of an outline of the area **330** and two sides respectively including two vertices p**3** and p**4** of an outline of the area **340**.

The position information of the group included in the warning information may include information indicating latitude/longitude coordinates of a central point P**3** of the area A**3**. The position information of the group included in the warning information may include information indicating latitude/longitude coordinates of the central point P**3** of the area A**3** and a size of the area A**3**. The position information of the group included in the warning information may include information indicating the latitude/longitude coordinates of the central point P**3** of the area A**3** and lengths of two sides of an outline of the area A**3**. The position information of the group included in the warning information may include information indicating latitude/longitude coordinates of two diagonal vertices P**4** and P**5** of the area A**3**.

It should be noted that the position information of the group included in the warning information may indicate an area having any shape other than a rectangular shape. The position information of the group included in the warning information may indicate a circular, an elliptic, or any polygonal area. Moreover, the position information of the group included in the warning information may include average coordinates of latitude/longitude coordinates of a plurality of pedestrians **80**.

FIG. **5** roughly shows a processing flow related to a warning control method executed by a vehicle **20** and a terminal **82**. FIG. **5** shows a processing flow for a case where a warning control apparatus **24** transmits warning information to the terminal **82** via direct communication.

In S**600**, a communication environment information obtainment unit **242** obtains communication environment information. For example, the communication environment information obtainment unit **242** obtains information indicating a congestion level of communication. In S**602**, an obtainment unit **220** recognizes a position and a moving speed of each of a plurality of pedestrians **80** based on an image captured by a camera **22** and ranging information from a radar **21**.

In S**604**, a classification unit **240** classifies the pedestrians **80** recognized in S**602** into one or more groups. For

example, the classification unit **240** classifies the pedestrians **80** into the one or more groups at least based on positions and moving directions of the pedestrians **80**. For example, the classification unit **240** classifies a plurality of pedestrians **80** having higher coincidence levels of position and moving speed of the pedestrians **80** than predetermined values, into one group.

In S**606**, a risk level determination unit **222** determines, for each of the groups obtained through the classification in S**604**, a position and a moving speed of the group. For example, the risk level determination unit **222** determines, as the position of the group, average coordinates of latitude/longitude coordinates of the positions of the pedestrians **80** classified into a same group. Moreover, as described in association with FIG. **3** and FIG. **4**, the risk level determination unit **222** may determine, as the position of the group, latitude/longitude coordinates indicating an area including ranges occupied by the pedestrians **80** classified into each group. Moreover, the risk level determination unit **222** determines, as the moving speed of the group, an average speed of moving speeds at the positions of the pedestrians **80** classified into the same group.

In S**608**, the risk level determination unit **222** determines a risk level against the vehicle **20** for each of the groups. The risk level determination unit **222** sets the risk level of the group high when a moving direction of the group is towards a roadway **70**. The risk level determination unit **222** sets the risk level of the group higher as the moving speed of the group in the direction towards the roadway **70** is higher. The risk level determination unit **222** sets the risk level of the group higher as the position of the group is closer to the roadway **70**. The risk level determination unit **222** sets the risk level high when a distance that the group can move within a time required for the vehicle **20** to reach the position of the group in its driving direction is longer than a distance from the position of the group to the roadway **70**. The risk level determination unit **222** sets the risk level of the group including the pedestrian **80** recognized as a child high.

In S**610**, a selection unit **230** selects, based on the risk level determined in S**608**, a group to be transmitted the warning information among the groups obtained through the classification in S**604**. The selection unit **230** selects, as a group to be warned, a group determined to have a higher risk level than a predetermined risk level in S**606**. For example, the selection unit **230** selects, as the group to be transmitted the warning information, a group determined to have a risk level of "high" or "moderate".

It should be noted that the selection unit **230** may determine an upper limit of a number of at least one time that the warning information is transmitted, based on the congestion level of communication obtained by the communication environment information obtainment unit **242** in S**600**. For example, the selection unit **230** reduces the number of times that the warning information is transmitted, as the congestion level of communication is higher. The selection unit **230** may preferentially select a group having a higher risk level as the group to be transmitted the warning information, such that a number of at least one group to be transmitted the warning information is equal to or smaller than the upper limit.

In S**612**, a transmission control unit **250** causes warning information including the position information of each group determined in S**606** and the risk level of each group determined in S**608** to be transmitted by broadcasting. It should be noted that, when a plurality of pieces of warning information is transmitted, the transmission control unit **250** may cause the plurality of pieces of warning information to be transmitted in one transmission data. When a plurality of pieces of warning information is transmitted, the transmission control unit **250** may cause the plurality of pieces of warning information to be transmitted as separate transmission data.

When receiving the warning information, in S**620**, the terminal **82** identifies, based on the position information of the group included in the warning information, an area occupied by the pedestrians classified into each group, and determines whether a current position of the terminal **82** itself is included in the identified area. In S**622**, when the current position of the terminal **82** itself is included in the area identified based on the position information of the group included in the warning information, the terminal **82** outputs an alarm through an HMI function of the terminal **82** itself depending on the risk level included in the warning information. Terminal **82** may output alarm information having a higher alarm level as the risk level included in the warning information is higher. For example, the terminal **82** may give an alarm with vibration when the risk level included in the warning information is "moderate", while giving an alarm with voice and vibration when the risk level included in the warning information is "high".

It should be noted that, when outputting an alarm, the terminal **82** may instruct another terminal **82** located nearby to output an alarm. For example, the terminal **82** may instruct another terminal **82** correlated in advance to output an alarm. Specifically, the terminal **82** outputting an alarm may instruct another terminal **82** carried by its contractor's family member to output an alarm. The terminal **82** outputting an alarm may instruct another predetermined terminal **82** paired via Bluetooth (registered trademark) or the like to output an alarm. The terminal **82** outputting an alarm may instruct, via Near Field Communication, another terminal **82** located in a vicinity to output an alarm.

It should be noted that, as described in S**610**, the selection unit **230** may select the group to be transmitted the warning information, such that the number of groups to be transmitted the warning information is equal to or smaller than the upper limit determined by the congestion level of communication. However, for example, when the classification classifies the pedestrians into many groups, the group determined to have a high risk level may not be selected as the target to be transmitted the warning information. In this case, selecting parameters used for the classification in S**604** may set the number of groups to be transmitted the warning information in S**610** to be equal to or smaller than the upper limit determined by the congestion level of communication. For example, repeating the processing from S**604** to S**610** multiple times by changing the parameters used for the classification in S**604** may set the number of groups to be transmitted the warning information to be equal to or smaller than the upper limit determined by the congestion level of communication. For example, if the classification is made in S**604** by using the position and the moving speed of the group as the parameters, when the number of groups to be transmitted the warning information in S**610** cannot be set to be equal to or smaller than the upper limit determined by the congestion level of communication, executing the processing from S**604** again and making the classification in S**604** by using the position and the moving direction of the group as the parameters may set the number of groups to be transmitted the warning information to be equal to or smaller than the upper limit determined by the congestion level of communication.

FIG. **6** roughly shows another processing flow related to the warning control method executed by the vehicle **20**, a

server **52** and the terminal **82**. FIG. **6** shows a processing flow for a case where the warning control apparatus **24** transmits the warning information to the terminal **82** via the server **52**. The server **52** collects and stores current position information of the terminal **82**. Since the processing from S**600** to S**610** in FIG. **6** is the same as the processing from S**600** to S**610** described in association with FIG. **5**, description of the former will be omitted.

In S**614**, the transmission control unit **250** causes the warning information including the position information of each group determined in S**606** to be transmitted to the server **52**. When receiving the warning information, the server **52** selects, based on the position information of each group included in the warning information, the terminal **82** present in the area occupied by the pedestrians classified into each group. For example, the server **52** selects, with reference to the current position information of the terminal **82** stored by the server **52**, the terminal **82** whose current position is present in the area of each group identified from the position information of each group included in the warning information.

In S**632**, the server **52** transmits the warning information to the terminal **82** selected in S**630**. In S**640**, the terminal **82** having received the warning information transmitted from the server **52** outputs an alarm through the HMI function of the terminal **82**.

It should be noted that a driver-assistance control apparatus **30** may provide driver-assistance along with the transmission of the warning information in S**612** of FIG. **5** or S**614** of FIG. **6**. For example, when a positional relationship between the pedestrian **80** and the vehicle **20** satisfies a predetermined condition, the driver-assistance control apparatus **30** may give notice to the pedestrian **80** that the vehicle **20** is approaching, by decelerating the vehicle **20** or performing beam passing or horn announcement with an Advanced Emergency Braking System function.

As described above, in the warning system **10**, the warning control apparatus **24** can classify the pedestrians **80** to be transmitted the warning information into the number of groups smaller than the number of pedestrians **80**, to specify the position information of the group and transmit the warning information. Therefore, it is possible to reduce a communication resource used for the transmission of the warning information. This can reduce a possibility that the warning information can no longer be transmitted, even in a situation where there are many pedestrians **80** to be transmitted the warning information. Moreover, it is possible to reduce a possibility that the warning information is redundantly transmitted to the plurality of pedestrians **80** located close to one another, as compared with a case where the warning information including the position information of each of the pedestrians **80** is transmitted. Moreover, the warning control apparatus **24** determines the risk level by putting the pedestrians **80** together into a small number of groups, so that a calculating amount can be reduced as compared with a case where the risk level is determined for all of the pedestrians **80**.

It should be noted that, in the above description, a configuration has been described in which the recognition information on the position of the pedestrian **80** is obtained by the vehicle **20** recognizing the position of the pedestrian **80**. However, a configuration can be adopted in which the recognition information on the position of the pedestrian **80** recognized by the server **52** or another vehicle is obtained from the server **52** or the other vehicle.

It should be noted that communication between the warning control apparatus **24** and the terminal **82** may be performed via short-range direct communication in Cellular-V2X. The short-range direct communication in Cellular-V2X includes a communication system such as LTE-V2X PC5 or 5G-V2X PC5. A configuration may be adopted in which Wi-Fi (registered trademark) or Dedicated Short Range Communications (DSRC) is used as direct communication. The warning control apparatus **24** may communicate with the terminal **82** via a base station. Moreover, the communication between the warning control apparatus **24** and the terminal **82** may adopt any direct communication system such as Bluetooth (registered trademark) in addition to Cellular-V2X and DSRC (registered trademark). The warning control apparatus **24** may perform direct communication with the terminal **82** by using a communication infrastructure included in Intelligent Transport Systems (ITS).

It should be noted that the vehicle **20** is one example of transportation equipment. The transportation equipment includes, for example, an automobile such as a passenger vehicle or a bus, a saddle-ride type vehicle, and a bicycle. Moreover, the moving object includes not only a person but also transportation equipment, for example, an automobile such as a passenger vehicle or a bus, a saddle-ride type vehicle, and a bicycle.

FIG. **7** shows an example of a computer **2000** where a plurality of embodiments of the present invention may be entirely or partially embodied. A program installed on the computer **2000** can cause the computer **2000** to function as an apparatus such as the warning control apparatus **24** according to the embodiments or each unit of that apparatus, to execute operations associated with that apparatus or each unit of that apparatus, and/or to execute a process according to the embodiments or steps of that process. Such a program may be executed by a CPU **2012** in order to cause the computer **2000** to execute a specific operation associated with some or all of the processing procedures and the blocks in the block diagrams described herein.

The computer **2000** according to this embodiment includes the CPU **2012** and a RAM **2014**, which are mutually connected by a host controller **2010**. The computer **2000** also includes a ROM **2026**, a flash memory **2024**, a communication interface **2022**, and an input/output chip **2040**. The ROM **2026**, the flash memory **2024**, the communication interface **2022**, and the input/output chip **2040** are connected to the host controller **2010** via an input/output controller **2020**.

The CPU **2012** operates according to the programs stored in the ROM **2026** and the RAM **2014**, thereby controlling each unit.

The communication interface **2022** communicates with other electronic devices via a network. The flash memory **2024** stores programs and data used by the CPU **2012** in the computer **2000**. The ROM **2026** stores a boot program or the like that is executed by the computer **2000** during activation, and/or a program that depends on hardware of the computer **2000**. The input/output chip **2040** may also connect various input/output units such as a keyboard, a mouse, and a monitor to the input/output controller **2020** via an input/output port such as a serial port, a parallel port, a keyboard port, a mouse port, a monitor port, a USB port, an HDMI (registered trademark) port.

A program is provided via a computer-readable medium such as a CD-ROM, a DVD-ROM, or a memory card, or a network. The RAM **2014**, the ROM **2026**, or the flash memory **2024** is an example of the computer-readable medium. The program is installed in the flash memory **2024**, the RAM **2014**, or the ROM **2026**, and is executed by the

CPU **2012**. Information processing written in these programs is read by the computer **2000**, resulting in cooperation between a program and the above described various types of hardware resources. An apparatus or a method may be configured by realizing operations or processing of information according to a use of the computer **2000**.

For example, when communication is performed between the computer **2000** and an external device, the CPU **2012** may execute a communication program loaded in the RAM **2014**, and instruct the communication interface **2022** to execute communication processing based on processing written in the communication program. Under the control of the CPU **2012**, the communication interface **2022** reads transmission data stored in a transmission buffer processing region provided in a recording medium such as the RAM **2014** or the flash memory **2024**, transmits the read transmission data to the network, and writes reception data received from the network into a reception buffer processing region or the like provided on the recording medium.

Moreover, the CPU **2012** may cause all or a necessary portion of a file or a database stored in a recording medium such as the flash memory **2024** to be read into the RAM **2014**, and execute various types of processing on the data on the RAM **2014**. The CPU **2012** then writes back the processed data into the recording medium.

Various types of information such as various types of programs, data, a table, and a database may be stored in the recording medium and may be subjected to information processing. The CPU **2012** may execute, on the data read from the RAM **2014**, various types of processing including various types of operations, information processing, conditional judgement, conditional branching, unconditional branching, information retrieval and replacement, or the like described herein and specified by instruction sequences of the programs, and write back a result into the RAM **2014**. Moreover, the CPU **2012** may search for information in a file, a database, or the like in the recording medium. For example, when the recording medium stores a plurality of entries, each having an attribute value of a first attribute associated with an attribute value of a second attribute, the CPU **2012** may search for an entry having a specified attribute value of the first attribute that matches a condition among the plurality of entries, and read the attribute value of the second attribute stored in the entry, thereby obtaining the attribute value of the second attribute associated with the first attribute that satisfies a predetermined condition.

A program or a software module described above may be stored in a computer-readable medium on the computer **2000** or in a vicinity of the computer **2000**. A recording medium such as a hard disk or a RAM provided in a server system connected to a dedicated communication network or the Internet can be used as a computer-readable medium. The program stored in the computer-readable medium may be provided to the computer **2000** via the network.

The program installed on the computer **2000** and causes the computer **2000** to function as the control unit **200** may work on the CPU **2012** or the like to cause the computer **2000** to function as each unit of the control unit **200**, respectively. Information processing written in these programs is read by the computer **2000**, thereby functioning as each unit of the control unit **200** which is specific means in which software and a variety of hardware resources mentioned above cooperate with each other. By realizing operations or processing of information according to the intended use of the computer **2000** according to this embodiment using these specific means, the control unit **200** specific to the intended use is constructed.

Various embodiments have been described with reference to the block diagrams and the like. In the block diagrams, each block may represent (1) a step of a process in which an operation is executed, or (2) each unit of the apparatus having a role in executing the operation. Specific steps and each unit may be implemented by a dedicated circuit, a programmable circuit supplied along with a computer-readable instruction stored on a computer-readable medium, and/or a processor supplied along with the computer-readable instruction stored on the computer-readable medium. The dedicated circuit may include a digital and/or analog hardware circuit, or may include an integrated circuit (IC) and/or a discrete circuit. The programmable circuit may include a reconfigurable hardware circuit including logical AND, logical OR, logical XOR, logical NAND, logical NOR, and other logical operations, and a memory element such as a flip-flop, a register, a field-programmable gate array (FPGA), a programmable logic array (PLA), or the like.

The computer-readable medium may include any tangible device capable of storing an instruction executed by an appropriate device, and as a result, the computer-readable medium having the instruction stored thereon constitutes at least a part of a product including an instruction that may be executed in order to provide means to execute an operation specified by a processing procedure or a block diagram. Examples of computer-readable media may include an electronic storage medium, a magnetic storage medium, an optical storage medium, an electromagnetic storage medium, a semiconductor storage medium, or the like. More specific examples of the computer-readable medium may include a floppy (registered trademark) disk, a diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or flash memory), an electrically erasable programmable read-only memory (EEPROM), a static random access memory (SRAM), a compact disk read-only memory (CD-ROM), a digital versatile disk (DVD), a Blu-ray (registered trademark) disk, a memory stick, an integrated circuit card, and the like.

The computer-readable instruction may include: an assembler instruction, an instruction-set-architecture (ISA) instruction; a machine instruction; a machine dependent instruction; a microcode; a firmware instruction; state-setting data; or either a source code or an object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk (registered trademark), JAVA (registered trademark), C++, or the like; and a conventional procedural programming language such as a "C" programming language or a similar programming language.

Computer-readable instructions may be provided to a processor of a general purpose computer, a special purpose computer, or other programmable data processing unit, or to programmable circuit, locally or via a local area network (LAN), wide area network (WAN) such as the Internet, and a computer-readable instruction may be executed to provide means to execute operations specified in the described processing procedures or block diagrams. Examples of the processor include a computer processor, a processing unit, a microprocessor, a digital signal processor, a controller, a microcontroller, and the like.

While the embodiments of the present invention have been described, the technical scope of the invention is not limited to the above described embodiments. It is apparent to persons skilled in the art that various alterations and improvements can be added to the above described embodi-

ments. It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the process must be performed in this order.

EXPLANATION OF REFERENCES

10: warning system
20: vehicle
21: radar
22: camera
24: control apparatus
25: GNSS receiving unit
26: vehicle speed sensor
29: sensor
30: driver-assistance control apparatus
48: communication apparatus
50: base station
52: server
70: roadway
72: walkway
80: pedestrian
82: terminal
200: control unit
220: obtainment unit
222: risk level determination unit
224: attribute information obtainment unit
230: selection unit
240: classification unit
242: communication environment information obtainment unit
250: transmission control unit
280: storage unit
310, **320**, **330**, **340**: area
2000: computer
2010: host controller
2012: CPU
2014: RAM
2020: input/output controller
2022: communication interface
2024: flash memory
2026: ROM
2040: input/output chip

What is claimed is:

1. A warning control apparatus comprising:

one or more processors and one or more non-transitory computer-readable storage media storing program instructions such that when the program instructions are executed by the one or more processors,

one or more processors are configured to

obtain recognition information including position information and a moving direction of each of a plurality of targets present outside a moving object;

classify the plurality of targets into one or more groups based on the obtained position information and the obtained moving direction of each of the plurality of targets;

determine, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches the moving object;

select, based on the risk level, one or more selected groups that are to be warned from the one or more groups;

control transmission of warning information including the position information of the one or more selected groups; and

obtain information indicating a communication environment,

wherein

the one or more processors are further configured to determine, based on the communication environment, a number of the one or more groups into which the plurality of targets are classified,

the one or more processors are further configured to obtain information indicating a congestion level of the communication environment,

the one or more processors are further configured to reduce the number of the one or more groups into which the plurality of targets are classified as the congestion level of the communication environment is higher, and

the one or more processors are further configured to transmit the warning information to one or more terminals corresponding to one or more of the plurality of targets that are to be warned, such that the one or more terminals output alarms to the corresponding one or more of the plurality of targets that are to be warned.

2. The warning control apparatus according to claim **1**, wherein

the recognition information includes the position information, the moving direction, and a moving speed of each of the plurality of targets present outside the moving object, and

the one or more processors are further configured to classify the plurality of targets into the one or more groups based on the position information, the moving direction, and the moving speed of each of the plurality of targets.

3. The warning control apparatus according to claim **2**, wherein

the one or more processors are further configured to control the transmission of the warning information including central coordinates of position information of the one or more of the plurality of targets that are to be warned as classified into each of the one or more selected groups.

4. The warning control apparatus according to claim **2**, wherein

the one or more processors are further configured to control the transmission of the warning information including a plurality of pieces of coordinate information indicating an area including position information of the one or more of the plurality of targets that are to be warned as classified into each of the one or more selected groups.

5. The warning control apparatus according to claim **1**, wherein

the one or more processors are further configured to control the transmission of the warning information including central coordinates of position information of the one or more of the plurality of targets that are to be warned as classified into each of the one or more selected groups.

6. The warning control apparatus according to claim 1, wherein

the one or more processors are further configured to control the transmission of the warning information including a plurality of pieces of coordinate information indicating an area including position information of the one or more of the plurality of targets that are to be warned as classified into each of the one or more selected groups.

7. The warning control apparatus according to claim 1, wherein

the one or more processors are further configured to obtain the recognition information by performing image recognition of an image captured by a camera mounted on the moving object.

8. The warning control apparatus according to claim 1, wherein

the one or more processors are further configured to control the transmission of the warning information performed without specifying a destination.

9. The warning control apparatus according to claim 1, wherein

the moving object is a vehicle.

10. A moving object comprising the warning control apparatus according to claim 1.

11. A warning control apparatus comprising:

one or more processors and one or more non-transitory computer-readable storage media storing program instructions such that when the program instructions are executed by the one or more processors,

one or more processors are configured to

obtain recognition information including position information and a moving direction of each of a plurality of targets present outside a moving object;

classify the plurality of targets into one or more groups based on the obtained position information and the obtained moving direction of each of the plurality of targets;

determine, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches the moving object;

select, based on the risk level, one or more selected groups that are to be warned from the one or more groups; and

control transmission of warning information including the position information of the one or more selected groups,

wherein

the plurality of targets are persons,

the one or more processors are further configured to obtain information indicating an age of each of the plurality of targets,

the one or more processors are further configured to determine, when at least one of targets classified into each of the one or more groups has an age included in a predetermined age group, the risk level to be higher than when none of targets classified into each of the one or more groups has an age included in the predetermined age group, and

the one or more processors are further configured to transmit the warning information to one or more terminals corresponding to one or more of the plurality of targets that are to be warned, such that the one or more terminals output alarms to the corresponding one or more of the plurality of targets that are to be warned.

12. A warning control apparatus comprising:

one or more processors and one or more non-transitory computer-readable storage media storing program instructions such that when the program instructions are executed by the one or more processors,

one or more processors are configured to

obtain recognition information including position information and a moving direction of each of a plurality of targets present outside a moving object;

classify the plurality of targets into one or more groups based on the obtained position information and the obtained moving direction of each of the plurality of targets;

determine, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches the moving object;

select, based on the risk level, one or more selected groups that are to be warned from the one or more groups; and

control transmission of warning information including the position information of the one or more selected groups,

wherein

the one or more processors are further configured to transmit the warning information to a server managing position information of a plurality of mobile terminals and to control the transmission of the warning information performed through the server, and

the one or more processors are further configured to transmit the warning information to one or more terminals corresponding to one or more of the plurality of targets that are to be warned, such that the one or more terminals output alarms to the corresponding one or more of the plurality of targets that are to be warned.

13. A warning control method comprising:

obtaining recognition information including position information and a current moving direction of each of a plurality of targets present outside a moving object;

classifying the plurality of targets into one or more groups based on the obtained position information and the obtained moving direction of each of the plurality of targets;

determining, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches the moving object;

selecting, based on the determined risk level, one or more selected groups that are to be warned from the one or more groups;

controlling transmission of warning information, including the position information of the one or more selected groups, so as to transmit the warning information to one or more terminals corresponding to one or more of the plurality of targets that are to be warned, such that the one or more terminals output alarms to the corresponding one or more of the plurality of targets that are to be warned;

obtaining information indicating a congestion level of a communication environment;

determining, based on the communication environment, a number of the one or more groups into which the plurality of targets are classified; and

reducing the number of the one or more groups into which the plurality of targets are classified as the congestion level of the communication environment is higher.

14. A non-transitory computer-readable storage medium having stored thereon a program that causes a computer to execute operations comprising:

obtaining recognition information including position information and a moving direction of each of a plurality of targets present outside a moving object;

classifying the plurality of targets into one or more groups based on the obtained position information and the obtained moving direction of each of the plurality of targets;

determining, based on position information and a moving direction of the group, a risk level at which each of the one or more groups approaches the moving object;

selecting, based on the determined risk level, one or more selected groups that are to be warned from the one or more groups;

controlling transmission of warning information including the position information of the one or more selected groups, so as to transmit the warning information to one or more terminals corresponding to one or more of the plurality of targets that are to be warned, such that the one or more terminals output alarms to the corresponding one or more of the plurality of targets that are to be warned;

obtaining information indicating a congestion level of a communication environment;

determining, based on the communication environment, a number of the one or more groups into which the plurality of targets are classified; and

reducing the number of the one or more groups into which the plurality of targets are classified as the congestion level of the communication environment is higher.

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