[0007] An object of the present disclosure is to provide a flight management apparatus, a flying object, a flight management system, a distributed system, a flight management method, a flight control method and a program capable of improving the safety of flying objects.

Solution to Problem

[0007a] Aspects of the invention are defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

[0008] In a first example, an exemplary flight management apparatus includes:

a receiving unit configured to receive, from one of a plurality of flying objects, request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

a determination unit configured to determine whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell, when the receiving unit receives the request; and

a permission unit configured to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is not reserved for another flying object, and not to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is already reserved for another flying object.

[0009] In a second example, an exemplary flying object includes:

a request generation unit configured to determine own flight route and generate a request for permission to move to a specific space cell on the flight route in a space;

a transmission unit configured to transmit the request, generated by the request generation unit, to a flight management apparatus; and

a flight control unit configured to move an airframe to the specific space cell when the specific space cell is not reserved by another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not to move the airframe to the specific space cell when the specific space cell is already reserved by another flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus, wherein

the request generation unit updates the flight route based on the non-permission information received from the flight management apparatus.

[0010] In a third example, an exemplary flight management system includes:

a plurality of flying objects; and

a flight management apparatus for managing the plurality of flying objects,

wherein each of the plurality of flying objects includes:

a request generation unit configured to determine own flight route and generate a request for permission to move to a specific space cell on the flight route in a space;

a request transmission unit configured to transmit the request, generated by the request generation unit, to the flight management apparatus; and

wherein the flight management apparatus includes:

a receiving unit configured to receive the request from one of the plurality of flying objects;

a determination unit configured to determine whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell, when the receiving unit receives the request; and

a permission unit configured to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is not reserved for another flying object and not to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is already reserved for another flying object.

[0011] In a fourth example, an exemplary distributed system includes:

a plurality of flying objects;

wherein each of the plurality of flying objects includes a communication unit configured to communicate with other flying objects using a peer-to-peer communication system to form the distributed system including the flying object itself and the other flying objects, and an adjudication unit configured to cause the communication unit to transmit its own vote with a predetermined weighting for a specific space cell in a space to the other flying objects; and

the adjudication unit of the flying object which transmitted the heaviest weighted vote executes an adjudication of which flying object the specific space cell is to be allocated.

[0012] In a fifth example, an exemplary flight management method includes:

receiving, from one of a plurality of flying objects, a request for permission to move to a specific space cell in a space on a flight route of the one flying object determined

by the one flying object;

determining whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell; and

permitting the movement to the specific space cell of the one flying object when determining the specific space cell is not reserved for another flying object and not permitting the movement to the specific space cell of the one flying object when determining the specific space cell is already reserved for another flying object.

[0013] In a sixth example, an exemplary flight control method includes:

determining own flight route,

generating a request for permission to move to a specific space cell on the flight route in a space;

transmitting the request to a flight management apparatus;

moving an airframe to the specific space cell when the specific space cell is not reserved by another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not moving the airframe to the specific space cell when the specific space cell is already reserved by another flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus; and

updating the flight route based on the non-permission information received from the flight management apparatus.

[0014] In a seventh example, an exemplary program for causing a computer to execute:

receiving, from one of a plurality of flying objects, a request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

determining whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell; and

permitting the movement to the specific space cell of the one flying object when determining the specific space cell is not reserved for another flying object and not permitting the movement to the specific space cell of the one flying object when determining the specific space cell is already reserved for another flying object.

[0015] In an eighth example, an exemplary program for causing a computer to execute:

determining own flight route,

generating a request for permission to move to a specific space cell on the flight route in a space;

transmitting the request to a flight management apparatus;

moving an airframe to the specific space cell when the specific space cell is not reserved by another flying object and receiving permission information permitting movement to the specific space cell from the flight management apparatus, and not moving the airframe to the specific space cell when the specific space cell is already reserved by another flying object and receiving non-permission information not permitting the movement to the specific space cell from the flight management apparatus; and

updating the flight route based on the non-permission information received from the flight management apparatus.

[**CLAIMS**]

[Claim 1]

A flight management apparatus comprising:

a receiving unit configured to receive, from one of a plurality of flying objects, a first request for permission to move to a specific space cell, the specific space cell being in a space on a flight route of the one flying object determined by the one flying object;

a determination unit configured to determine whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state of the specific space cell, when the receiving unit receives the first request;

a permission unit configured to permit movement of the one flying object to the specific space cell when the determination unit determines that the specific space cell is not reserved for the other flying object, and not to permit the movement of the one flying object to the specific space cell when the determination unit determines that the specific space cell is already reserved for the other flying object;

a voting unit configured to transmit, to the plurality of flying objects, its own vote with a weighting for the specific space cell in the space; and

an adjudication unit configured to execute an adjudication to determine which one of the plurality of flying objects is allocated the specific space cell.

[Claim 2]

The flight management apparatus according to Claim 1, further comprising:

a transmission unit configured to transmit, to the one flying object, non-permission information indicating that the permission unit does not permit the movement of the one flying object to the specific space cell when the permission unit does not permit it; and

wherein the determination unit is configured to determine whether another space cell in the space other than the specific space cell is already reserved for the other flying object based on a reservation state of the other space cell, when the receiving unit receives a second request from the one flying object requesting permission to move to the other space cell after the transmission unit transmits the non-permission information; and

the permission unit is configured to permit the movement of the one flying object to the other space cell when the determination unit determines that the other space cell is not reserved for the other flying object, and not to permit the movement of the one flying object to the other space cell when the determination unit determines that the other space cell is already reserved for the other flying object.

[Claim 3]

The flight management apparatus according to Claim 1 or 2, further comprising:

a first memory configured to store reservation states of the plurality of flying objects related to a plurality of space cells into which the space is divided; and

wherein the flight management apparatus is configured to cancel the reservation state of a space cell related to a third request, being for canceling the reservation of the space cell passed by the one flying object, when the flight management apparatus receives the third request from the one flying object.

[Claim 4]

The flight management apparatus according to any one of Claims 1 to 3, further comprising:

a second memory configured to store reservation states of a plurality of space cells into which the space is divided; and

a movement management unit configured to control the plurality of flying objects to fly two-dimensionally in a plane constituted of space cells of the same height to manage traffic of the plurality of flying objects in the plane.

[Claim 5]

The flight management apparatus according to Claim 4,

wherein the movement management unit is configured to permit movement of the plurality of flying objects in a predetermined axial direction in the plane, and not to permit movement in any other direction.

[Claim 6]

The flight management apparatus according to Claim 5,

wherein the movement management unit is configured to set a plurality of lanes for moving the plurality of flying objects in the predetermined axial direction in the plane, the plurality of lanes having reference speeds of the plurality of flying objects different from each other.

[Claim 7]

The flight management apparatus according to Claim 5,

wherein the movement management unit is configured to set a plurality of lanes for moving the plurality of flying objects in the predetermined axial direction in the plane, and further configured to determine a moving direction for each of the plurality of lanes by using at least one of time information or date information.

[Claim 8]

The flight management apparatus according to any one of Claims 1 to 7, further comprising:

a third memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein the flight management apparatus is configured to change size of the plurality of space cells according to at least one of the locations where the plurality of space cells is located, or time information.

[Claim 9]

The flight management apparatus according to any one of Claims 1 to 8, further comprising:

a fourth memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein predetermined priority is set to the one flying object, and the flight management apparatus is configured to permit the one flying object having high priority to move to a predetermined space cell or to move in a predetermined direction from a predetermined space cell, and not to permit the one flying object having low priority to perform the movement.

[Claim 10]

The flight management apparatus according to any one of Claims 1 to 9, further comprising:

a fifth memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein the flight management apparatus is configured to switch, according to predetermined conditions, whether or not the one flying object can move to a predetermined space cell constituting an area where weather unsuitable for flight has occurred, or to a predetermined space cell in which a density of the plurality of flying objects in space cells surrounding the predetermined space cell is equal to or greater than a threshold value.

[Claim 11]

A flying object comprising:

a request generation unit configured to determine its own flight route and generate a first request for permission to move to a specific space cell on the flight route in a space;

a transmission unit configured to transmit the first request, generated by the request generation unit, to a flight management apparatus; and

a flight control unit configured to move an airframe of the flying object to the specific

space cell when the specific space cell is not reserved for another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not to move the airframe to the specific space cell when the specific space cell is already reserved by the other flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus,

wherein the request generation unit is configured to update the flight route based on the non-permission information received from the flight management apparatus,

the flying object further comprising:

a voting unit configured to transmit its own vote with a weighting for the specific space cell in the space to other flying objects; and

an adjudication unit configured to execute an adjudication to determine which one of a plurality of flying objects is allocated the specific space cell, the plurality of flying objects comprising the flying object and the other flying objects.

[Claim 12]

The flying object according to Claim 11,

wherein the request generation unit is configured to generate a second request for permission to move to another space cell other than the specific space cell, when the flying object receives the non-permission information; and

the transmission unit is configured to transmit the second request generated by the request generation unit to the flight management apparatus.

[Claim 13]

The flying object according to Claim 12,

wherein the request generation unit is configured to determine the other space cell by using at least one of a positional relationship between a present position and a destination, weather information, a remaining amount of resources necessary for the flight of the flying object, or a speed of the flying object.

[Claim 14]

A flight management system comprising:

the flight management apparatus according to any one of Claims 1 to 10; and

the flying object according to any one of Claims 11 to 13.

[Claim 15]

The flight management system according to Claim 14,

wherein the flight management system includes a first flight management apparatus and

a second flight management apparatus, each of the first and second flight management apparatuses being the flight management apparatus,

each of the first and second flight management apparatuses has a sixth memory configured to store reservation states of a plurality of space cells into which a space is divided, and a first space for which the first flight management apparatus stores the reservation state is different from a second space for which the second flight management apparatus stores the reservation state,

wherein, in response to the first flight management apparatus recognizing a flying object flying from the second space toward the first space and the receiving unit of the first flight management apparatus receiving a request for permission to move to a specific space cell in the first space from the flying object,

the determination unit of the first flight management apparatus is configured to determine whether or not the specific space cell is already reserved by the other flying object, and

the permission unit of the first flight management apparatus is configured to permit movement of the flying object to the specific space cell when the determination unit determines that the specific space cell is not reserved by the other flying object, and not to permit movement of the flying object to the specific space cell when the determination unit determines that the specific space cell is already reserved by the other flying object.

[Claim 16]

The flight management system according to Claim 14 or 15,

wherein the flight management apparatus further comprises a route proposal unit configured to propose a flight route of the flying object when the permission unit permits or does not permit the movement to the specific space cell, and

the request generation unit of the flying object is configured to determine the flight route by agreeing to all or part of the flight route proposed by the route proposal unit.

[Claim 17]

A flight management method comprising:

receiving, from one of a plurality of flying objects, a request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

determining whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state of the specific space cell;

permitting movement of the one flying object to the specific space cell when it is determined that the specific space cell is not reserved for the other flying object and not permitting the movement of the one flying object to the specific space cell when it is determined that the specific space cell is already reserved for the other flying object;

transmitting a vote with a weighting for the specific space cell to the plurality of flying objects; and

executing an adjudication to determine which one of the plurality of flying objects is allocated the specific space cell.

[Claim 18]

A flight control method of a flying object comprising:

determining its own flight route;

generating a request for permission to move to a specific space cell on the flight route in a space;

transmitting the request to a flight management apparatus;

moving an airframe of the flying object to the specific space cell when the specific space cell is not reserved by another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not moving the airframe to the specific space cell when the specific space cell is already reserved by the other flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus;

updating the flight route based on the non-permission information received from the flight management apparatus;

transmitting a vote with a weighting for the specific space cell to other flying objects; and

executing an adjudication to determine which one of a plurality of flying objects is allocated the specific space cell, the plurality of flying objects comprising the flying object and the other flying objects.

[Claim 19]

A program for causing a computer to execute the method according to Claim 17.

[Claim 20]

A program for causing a computer to execute the method according to Claim 18.