case, the second reflected wave can be radiated into a range including a direction orthogonal to the installation surface, and thus, a radiation range that is easily and intuitively understood can be obtained.

[0030]

(12) The plurality of reflectarray reflectors may include a first reflectarray reflector, a second reflectarray reflector, and a third reflectarray reflector. The first reflectarray reflector may be configured to form: a first reflected wave toward the second reflectarray reflector by reflecting a first incident wave having a first incident angle; and a second reflected wave toward the third reflectarray reflector by reflecting a second incident wave having a second incident angle different from the first incident angle. The second reflectarray reflector may be configured to form a third reflected wave by reflecting the first reflected wave. The third reflectarray reflector may be configured to form a fourth reflected wave by reflecting the second reflected wave. The third reflected wave and the fourth reflected wave may have radiation ranges overlapping each other. In this case, the overlapping radiation ranges of the third reflected wave and the fourth reflected wave can be enlarged, which is preferable.

[0031]

(13) The plurality of reflectarray reflectors may include a first reflectarray reflector, and a second reflectarray reflector. The reflection unit may further include a radio wave absorber. The first reflectarray reflector may be configured to form: a first reflected wave toward the second reflectarray reflector by reflecting a first incident wave having a first incident angle; and a second reflected wave toward the radio wave absorber by reflecting a second incident wave having a second incident angle different from the first incident angle. In this case, the second reflected wave can be absorbed.

[0032]

(14) The at least one reflectarray reflector may include a multi-focal point

concentrated at a focal point. In this case, the reflected wave can be caused to have a narrow beam width around a focal point.

[0045]

(27) The reflection unit may be mountable to a structure that has: a first portion; and a second portion where the wireless communication signal is more easily propagated than in the first portion. The concentration-type reflectarray reflector may be mounted to the structure such that the reflected wave passes through the second portion. In this case, the reflected wave having been caused to have a narrow beam width around a focal point can pass through the second portion.

[0046]

(28) The concentration-type reflectarray reflector may be configured such that the focal point is present at a position where an obstacle present in the wireless transmission path is avoided. In this case, the obstacle can be avoided.

[0047]

(29) The reflection unit can further include another reflector configured to further reflect the reflected wave. The other reflector may be smaller than the concentration-type reflectarray reflector. In this case, the other reflector can be downsized.

[0048]

(30) A wireless transmission system according to an embodiment includes: a first wireless device configured to at least transmit a wireless communication signal; a second wireless device configured to at least receive the wireless communication signal; and the reflection unit installed in a wireless transmission path between the first wireless device and the second wireless device in order to change a direction of the wireless transmission path.

[0049]

<Details of embodiments of the present disclosure>

Hereinafter, details of embodiments of the present disclosure will be described

adjusted, the reflectarray reflector 110 can radiate a reflected wave into a desired direction.

[0065]

Here, in general, a reflectarray is used as a part of an antenna. However, the reflectarray reflector 110 of the first embodiment does not form a part of an antenna of the wireless device 10, 20, but is used for reflecting, in a wireless transmission path, a radio wave (wireless communication signal) radiated from the wireless device 10, 20 that includes an antenna. That is, the reflectarray reflector 110 of the first embodiment is installed in a wireless transmission path in order to change the direction of the wireless transmission path between the first wireless device 10 and the second wireless device 20.

[0066]

With respect to diffusion or concentration of a reflected wave, the reflectarray reflector 110 can be designed so as to simulate reflection characteristics of a metal reflection surface having an arbitrary shape. In order to design the reflectarray reflector 110 that simulates the reflection characteristics of a metal reflection surface having an arbitrary shape, first, a phase change amount necessary for each reflection element 132 of the reflectarray reflector 110 is obtained from the reflection characteristics at the metal reflection surface to be simulated. There is a predetermined correspondence relationship between the phase change amount and the size or shape of the reflection element 132. Therefore, when the phase change amount is obtained, the size or shape of the reflection element 132 can be determined.

[0067]

Here, as for the reflection characteristics simulated by the reflectarray reflector 110, a reflection characteristic regarding diffusion or concentration of a reflected wave at the metal reflection surface is sufficient, and there is no need to simulate the direction of the reflected wave. As described above, in the case of a metal reflection surface, the direction of the reflected wave cannot be freely adjusted, but the reflectarray reflector 110 can radiate the

Therefore, the opening 30B having a small diameter is formed in a construction member such as the wall member 41 or the ceiling member 42. The opening 30B allows a radio wave having a high frequency such as a millimeter wave, to pass therethrough with a small loss. That is, in a construction member such as the wall member 41 or the ceiling member 42, the portion where the opening 30B is not formed is a first portion where the penetration loss is large, and the portion where the opening 30B is formed is a second portion where the penetration loss is small. The radio wave is more easily propagated through a second portion 30B than through a first portion 30A. When the reflectarray reflector 110 is of a concentration type, the reflected wave 61 is caused to have a smaller diameter than that of the second portion 30B, at the position of the second portion 30B being an opening. Therefore, inhibition of passing-through of the reflected wave 61 by a construction member such as the wall member 41 or the ceiling member 42 is suppressed. As a result, penetration loss is reduced.

[0128]

Here, when the reflectarray reflector 110 is of a non-concentration type, the opening 30B that has a size the same as or greater than that of the reflectarray reflector 110 is necessary in order to cause a radio wave to penetrate with a low loss. However, as shown in FIG. 22, since the reflectarray reflector 110 is of a concentration type and the focal point 61A is set in the vicinity of the opening 30B, the opening 30B may be small. Thus, the opening 30B can be easily formed. Since the opening 30B may be small, impairment of the appearance can be suppressed. It should be noted that the opening 30B may be blindfolded with a member such as a decorative plate 30C. When the decorative plate 30C is formed of a material that is thinner than the wall member 41 and that the radio wave easily penetrates, increase in penetration loss of the radio wave is suppressed.

[0129]

FIG. 24 shows an example in which the reflectors 111, 112 are respectively

installed at a plurality of corners 33, 34 in the structure 30. In FIG. 24, the incident wave 60 is reflected by the reflector 111, whereby the first reflected wave 61 that advances along the wall member 41A is formed. The first reflected wave 61 is reflected by the reflector 112, whereby the second reflected wave 62 is formed.

[0130]

When the plurality of reflectors 111, 112 are used to transmit a radio wave, it is appropriate to install the reflectors 111, 112 at the respective corners 33, 34 of the structure 30, when stability of the reflection surface, ease of installation, or inconspicuousness is taken into consideration. However, if the reflectors 111, 112 are installed at the corners 33, 34, the wireless transmission path has to be close to the wall member 41A. In particular, at the center of the transmission sector where the radius of the radio wave path (first Fresnel radius) becomes maximum, a large clearance is necessary between the first reflected wave 61 and the wall member 41A. As a result, the reflectors 111, 112 need to be installed away from the wall member 41A.

[0131]

However, as shown in FIG. 25, when the reflector 111, 112 are configured to form a concentration-type reflected wave and the focal point 61A is present in the vicinity of the center of the transmission sector, the clearance between the first reflected wave 61 and the wall member 41A can be reduced, which is preferable.

[0132]

In FIG. 25, a single reflector 111, 112 is installed at the corresponding corner 33, 34, but the present disclosure is not limited thereto. At each of the corners 33, 34, the reflection unit 100 according to the first embodiment may be installed or the concave curved surface metal plate 200C may be installed. The reflection unit 100 installed at each of the corners 33, 34 preferably includes the concentration-type reflectarray reflector 110C. More specifically, the

reflection unit 100 installed at each of the corners 33, 34 is preferably one of those of CASES 1-3, 2-3, 3-1.

[0133]

FIG. 26 shows the plane metal plate 200B installed at the wall member 41. The wall member 41 has an installation surface 47 for the plane metal plate 200B. The plane metal plate 200B may be installed in the vicinity of signage or digital signage.

[0134]

There are many chances that the user equipment 20 is used in front of signage or digital signage. Advertisers wish that people stop in front of signage or digital signage. However, even when there is a plane metal plate 200B installed in the vicinity of signage or digital signage and a radio wave 60, 61 is reflected as in FIG. 26, the radio wave 60, 61 is not visible, and thus, the user does not know in which direction the radio wave is reflected. In addition, it is difficult for installation workers of the plane metal plate 200B to know which direction the radio wave is reflected, and thus, it is difficult to perform appropriate installation work.

[0135]

A radiation direction (reflection direction) of a radio wave that is easily and intuitively understood by a person is the front direction of a reflector or the installation surface 47 of the reflector. Therefore, as shown in FIG. 27, it is conceivable to install the reflectarray reflector 110 at the installation surface 47. The reflectarray reflector 110 in FIG. 27 is configured to radiate the reflected wave 61 to a range including the front direction being a direction orthogonal to the installation surface 47. In the case of FIG. 27, since the reflected wave 61 is radiated in the front direction of the reflectarray reflector 110 or the installation surface 47, the radiation direction of the reflected wave 61, which is not visible, is easily and intuitively understood.

That is, between the second concentration reflection part 322 and the second non-concentration reflection part 332, a space having a predetermined size is provided. The space around the second non-concentration reflection part 332 is a second low reflection region 342. The second low reflection region 342 has a reflectance lower than the reflectance of the second non-concentration reflection part 332. The second low reflection region 342 may include a radio wave absorber 342a. A part of the reflected wave component 611b off the second non-concentration reflection part 332 is incident on the second low reflection region 342. The part of the reflected wave component 611b incident on the second low reflection region 342 is attenuated, and further, the part of the reflected wave component 611b incident on the radio wave absorber 342a is absorbed by the radio wave absorber 342a.

[0169]

With reference back to FIG. 36, when the first non-concentration reflection part 331 is a non-diffusion and non-concentration-type reflectarray, the reflected wave component 611b is not diffused and is not concentrated. That is, the reflected wave component 611b is radiated as a collimated beam to the second reflectarray reflector 312. When the shape and size of the first non-concentration reflection part 331 and the shape and size of the second non-concentration reflection part 332 are the same as or similar to each other, substantially all of the reflected wave component 611b is incident on the second non-concentration reflection part 332 in the second reflectarray reflector 312.

[0170]

As described above, substantially all of the reflected wave component 611a and at least a part of the reflected wave component 611b are incident on the second non-concentration reflection part 332. That is, most of the primary reflected wave 611 is incident on the second non-concentration reflection part 332.

[0171]

Similar to the first non-concentration reflection part 331, the second non-concentration reflection part 332 is, for example, a reflectarray (diffusion-type reflectarray) that simulates reflection characteristics of the convex curved surface metal plate 200A (see FIG. 3), or a reflectarray (non-diffusion and non-concentration-type reflectarray) that simulates reflection characteristics of the plane metal plate 200B (see FIG. 3). The second non-concentration reflection part 332 may be the convex curved surface metal plate 200A or the plane metal plate 200B.

[0172]

The primary reflected wave 611 is reflected by the second non-concentration reflection part 332, whereby a secondary reflected wave 621 advances in a direction (direction toward the user equipment 20) opposite to the X direction. In the example in FIG. 34, the secondary reflected wave 621 is not diffused and is not concentrated. That is, the secondary reflected wave 621 is radiated as a collimated beam to the user equipment 20. In this example, the second non-concentration reflection part 332 is a diffusion-type reflectarray (or the convex curved surface metal plate 200A). Accordingly, the primary reflected wave 611 having been converged is reflected as a collimated beam by the second non-concentration reflection part 332. The secondary reflected wave 621 may be a convergent beam that is converged toward the user equipment 20, or may be a diffuse beam that is diffused toward the user equipment 20.

[0173]

A noise radio wave is present in the space where the reflection unit 300 is disposed. The noise radio wave includes, for example, a reflected wave (multipath) which is a wireless communication signal reflected at a wall surface. Even if a noise radio wave different from the first incident wave 601 is incident on the first concentration reflection part 321 at an incident angle slightly different from the incident angle of the first incident wave 601, the reflected wave of the noise radio wave is incident on a position off the second non-concentration

concentration reflection part 332 is not converged and at least a part of the reflected wave component is incident on the first non-concentration reflection part 331. That is, most of the primary reflected wave 612 is incident on the first non-concentration reflection part 331.

[0177]

The primary reflected wave 612 is reflected by the first non-concentration reflection part 331, whereby a secondary reflected wave 622 advances in a direction (direction toward the base station 10) opposite to the Y direction. In the example in FIG. 35, the secondary reflected wave 622 is not diffused and is not concentrated. That is, the secondary reflected wave 622 is radiated as a collimated beam to the base station 10. In this example, the first non-concentration reflection part 331 is a diffusion-type reflectarray (or the convex curved surface metal plate 200A). Accordingly, the primary reflected wave 612 having been converged is reflected as a collimated beam by the first non-concentration reflection part 331. The secondary reflected wave 622 may be a convergent beam that is converged toward the base station 10, or may be a diffuse beam that is diffused toward the base station 10.

[0178]

With reference back to FIG. 33, the first concentration reflection part 321 has a ring shape, and the first non-concentration reflection part 331 is disposed on the inner side of the first concentration reflection part 321. A first low reflection region 341 is provided around the first non-concentration reflection part 331. The first low reflection region 341 has a reflectance lower than the reflectance of the first non-concentration reflection part 331. The first low reflection region 341 may include a radio wave absorber 341a. A noise radio wave is attenuated by the first low reflection region 341, and the noise radio wave incident on the radio wave absorber 341a is absorbed. Therefore, noise in wireless communication can be reduced.

[0179]

The first non-concentration reflection part 331 is attachable to and detachable

from the first concentration reflection part 321. Accordingly, the position of the first non-concentration reflection part 331 can be easily adjusted such that the primary reflected wave 612 is accurately incident on the first non-concentration reflection part 331. The second non-concentration reflection part 332 is attachable to and detachable from the second concentration reflection part 322. Accordingly, the position of the second non-concentration reflection part 332 can be easily adjusted such that the primary reflected wave 611 is accurately incident on the second non-concentration reflection part 332.

[0180]

In the second embodiment described above, the first non-concentration reflection part 331 is disposed on the inner side of the first concentration reflection part 321 having a ring shape, and the second non-concentration reflection part 332 is disposed on the inner side of the second concentration reflection part 322 having a ring shape. However, the present disclosure is not limited thereto. FIG. 37 shows a configuration of a first modification of the reflection unit according to the second embodiment. In the first modification, the first concentration reflection part 321 and the second concentration reflection part 322 each have a rectangular shape. In the first reflectarray reflector 311, the first non-concentration reflection part 331 is disposed at a position closer to the second face 31B than the first concentration reflection part 321. In the second reflectarray reflector 312, the second non-concentration reflection part 332 is disposed at a position closer to the first face 31A than the second concentration reflection part 322. Depending on the radio wave state in the space where the reflection unit 300 is disposed, when there are few noise radio waves near the wall (in the vicinity of the first face 31A and the second face 31B) and there are many noise radio waves at a position away from the wall, if the configuration as above is adopted, influence of noise in wireless communication can be reduced.

[0181]

FIG. 38 shows a configuration of a second modification of the reflection unit

submillimeter wave, or a radio signal having a frequency of a millimeter wave or a frequency higher than that of the millimeter wave. However, the present disclosure is not limited thereto. The reflection unit 300 may be used for reflection of a high frequency power signal for space power transmission. That is, the reflection unit 300 may be disposed between a feeding device (first wireless device) that transmits a high frequency power signal and a power receiving device (second wireless device) that receives the high frequency power signal, and the reflection unit 300 may change the direction of the transmission path of the high frequency power signal.

[0184]

The embodiments disclosed herein are merely illustrative in all aspects and are not restrictive. The scope of the present disclosure is defined by the scope of the claims rather than the embodiments described above, and is intended to include meaning equivalent to the scope of the claims and all modifications within the scope.

REFERENCE SIGNS LIST

[0185]

1 wireless transmission system

10 first wireless device (base station)

11 first base station

12 second base station

20 second wireless device (user equipment)

20A, 20B, 20C, 21, 22 user equipment

30 structure (architecture)

30A first portion

30B second portion (opening)

30C decorative plate