RECOMMENDATION ITU-R F.1704

Characteristics of multipoint-to-multipoint fixed wireless systems with mesh network topology operating in frequency bands above about 17 GHz

(Question ITU-R 107/9)

(2005)

Scope

This Recommendation provides guidance for the system configuration and characteristics of Multipoint-to-Multipoint (MP-MP) fixed wireless systems (FWSs) with mesh network topology operating in frequency bands above about 17 GHz. The Annex analyses improvement of availability and reduction of transmit power as well as route diversity effect and the required function for MP-MP systems.

The ITU Radiocommunication Assembly,

considering

a) that FWSs operate in various frequency bands above 17 GHz;

b) that various techniques for the use of these frequencies are being implemented by administrations;

c) that the radio-wave propagation characteristics above about 17 GHz are predominantly governed by precipitation fading and absorption and only suited to short range radio system applications in countries affected by rain (see Recommendation ITU-R P.837);

d) that the radio-wave propagation characteristics at these frequencies are known to differ in some respects from those of lower frequencies and that some of these differences might be exploited to the advantage of certain types of systems;

e) that the equipment designs might differ from those used in the lower frequency bands;

f) that new applications and network configurations are being used in high-density deployment of FWSs in bands above about 17 GHz;

g) that the high concentrations of service users in urban, suburban and industrial areas require high-density deployment of user terminals in these areas;

h) that MP-MP systems with mesh network topology would be effective because of their potential for route diversity;

j) that under certain conditions, a MP-MP system with mesh network topology may be considered as an effective technique for the improvement of availability and/or the reduction of the transmit power in deployment of FWSs operating in frequency bands above about 17 GHz,

recommends

that Annex 1 should be used as guidance for the system configuration and characteristics of MP-MP systems with mesh network topology operating in frequency bands above about 17 GHz.

Annex 1

System configuration and characteristics of MP-MP systems with mesh network topology operating in frequency bands above about 17 GHz

1 Introduction

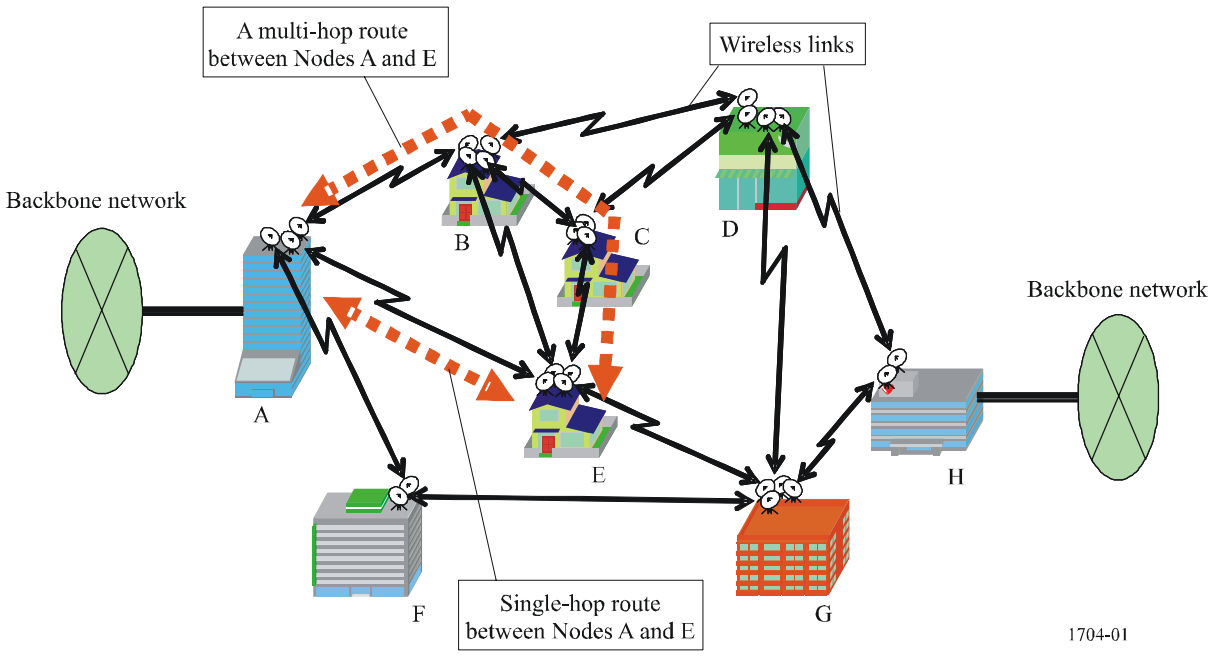
The use of MP-MP systems with mesh network topology are considered an effective means to mitigating the degradation of telecommunication quality in the FWSs operating in frequency bands above about 17 GHz. This Annex describes the overview of the system configuration for the MP-MP systems with mesh network topology and shows the results of the quantitative analysis on the improvement of availability and the reduction of transmit power due to the diversity gain utilizing mesh network topology. System functional requirements to maximize the route diversity effect and practical examples of the required functions are also shown. In addition, field experimental results on diversity gain are introduced (see Appendix 1 to this Annex).

2 Overview of system configuration

Figure 1 illustrates an example of MP-MP system with mesh network topology. The wireless mesh network consists of wireless nodes, which are either customer sites, relay nodes without originating/terminating traffic, or points of interface (POI) to other networks such as Internet service providers' (ISP) networks. A wireless node is connected to others via wireless links. The end-to-end traffic is conveyed over the single-hop route and/or multi-hop routes. Whereas the single-hop route consists of one wireless link, multi-hop routes consist of multiple wireless links. The entire network can be regarded as a MP-MP system. When at least one diversity route is available in the network, the system is specifically referred to as "an MP-MP system with mesh network topology".

FIGURE 1

An example of MP-MP system with mesh network topology



3 Improvement of availability and reduction of transmit power

MP-MP systems with mesh network topology have inherent capability for route diversity between a pair of nodes. The end-to-end telecommunication traffic is forwarded from a source node to a destination node via intermediate transient nodes, and there can be several routes between the pair of source and destination nodes. If one of the wireless links within a route between a pair of source and destination nodes become unavailable due to rain attenuation, the telecommunication traffic on the wireless route can be rerouted to other routes. Due to the route diversity effect, the availability of end-to-end telecommunications of the proposed mesh wireless network can be improved in comparison with the conventional P-P systems, P-MP systems, or MP-MP systems without mesh network topology.

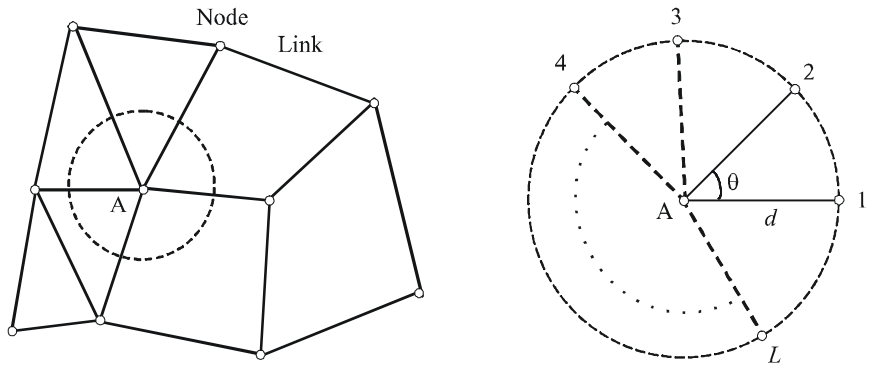
This section shows an analytical model and various numerical results of the analytical study on the improvement of availability and the diversity gain in MP-MP systems with mesh network topology. In the analytical model, the probability of simultaneous degradation of multiple links due to rain attenuation is expressed by the multivariate gamma distribution function with correlation.

3.1 Analytical model

Figure 2 depicts a mesh network to be evaluated. Multiple links connected to Node A within a mesh network (see Fig. 2a)) are simplified by a model (see Fig. 2b)), where multiple links provide *L*-branch diversity to Node A. In the simplified model, it is assumed that the separation angle θ between adjacent links is identical and all links have the same length *d*.

FIGURE 2

Wireless mesh network



a) General mesh topology

b) Simplified model with *L*-branch selection diversity

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3.1.1 Node unavailability

In Fig. 2b), Node A becomes unavailable when all links connected to the node are unavailable simultaneously. Hence, the probability that all the links providing the *L*-branch diversity are unavailable simultaneously is called node unavailability (i.e. outage probability), hereafter. Let X_i denote a stochastic variable for the rain attenuation of *i*-th link and $f(X_i, X_j, ..., X_k)$ be the joint probability density function of X_i, X_j, ... and X_k. The node unavailability $p_{NU}^{(L)}$, that is the probability that all the diversity branches to the node becomes unavailable simultaneously, is derived from:

$$p_{NU}^{(L)} = p_u^{12...L} \tag{1}$$