

Metrics For Multihop Systems

Document Number:

IEEE C802.16j-06/014

Date Submitted:

2006-05-01

Source:

Mark Naden, Dean Kitchener
Nortel
London Road
Harlow, Essex, CM17 9NA

Voice: +44 1279 402715
Fax: +44 1279 402100
E-mail: jmn@nortel.com

Wen Tong, Peiyong Zhu, Gamini Senarnath
Hang Zhang, David Steer, Derek Yu, Wang G-Q
Nortel, 3500 Carling Avenue
Ottawa, On K2H 8E9 Canada

Voice: 613 7658089 613 7631315
Email: pyzhu@nortel.com wentong@nortel.com

Venue:

IEEE 802.16 Session #43, TelAviv, Israel

Base Document:

None

Purpose:

To recommend performance metrics for multihop system

Notice:

This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

IEEE 802.16 Patent Policy:

The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <<http://ieee802.org/16/ipr/patents/policy.html>>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <<mailto:chair@wirelessman.org>> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <<http://ieee802.org/16/ipr/patents/notices>>.

Introduction

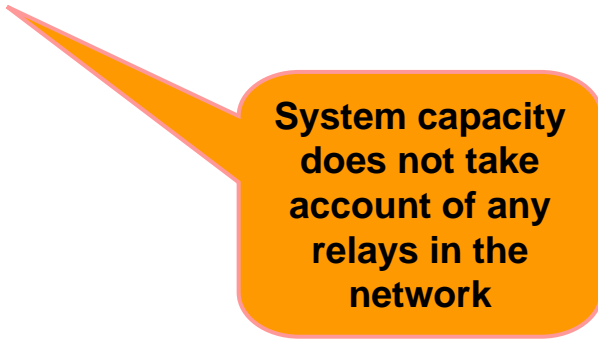
- **The choice of metric can significantly alter the perceived performance of a multihop system relative to a conventional cellular system**
 - For example, a metric that is based on the total number of sites, irrespective of whether they are base station or relay sites, will underestimate the performance of a multihop system because of the additional sites required for relays in the multihop network
 - Conversely, a metric that neglects the relays will overestimate the benefits of a multihop system: a multihop network optimised according to such a metric will contain an unrealistically low number of base stations and compensate by employing large numbers of relays
- **In this contribution, we describe a metric that enables a fair comparison of multihop networks with conventional cellular networks. The proposed metric may be used for the evaluation of MMR concepts and combines coverage and spectral efficiency and includes provision for the trade-off between base stations and relays in terms of overall system performance**

Coverage

- **Coverage is the probability that a randomly placed subscriber is able to reliably communicate at a particular data rate. It may also be expressed as the fractional area of a cell within which signal quality is high enough to support a specified service. If users are distributed uniformly within the cell, it is equivalent to the proportion of users that can receive a signal of sufficient quality**
- **Coverage enhancement is a primary objective for MMR. By improving coverage, a network operator may provide service to a greater proportion of the users in a cell, and users will experience more uniform access to the service. The inclusion of coverage as part of the metric is therefore valuable from both the network operator's perspective and from the user's perspective**

System Capacity

- **Whether or not a user is able to access the service also depends on the system capacity being sufficient to meet the demand for that service in his local area. System capacity enhancement is a secondary objective for MMR, as a system providing high capacity will be better able to meet the demand for a given service and hence to meet the user's requirements**
- **System capacity is a measure of the maximum total information rate supported by a base station. It is the total information rate per base station**
 - It is equivalent to the ratio of the total information rate supported per unit geographic area to the number of base stations per unit geographic area

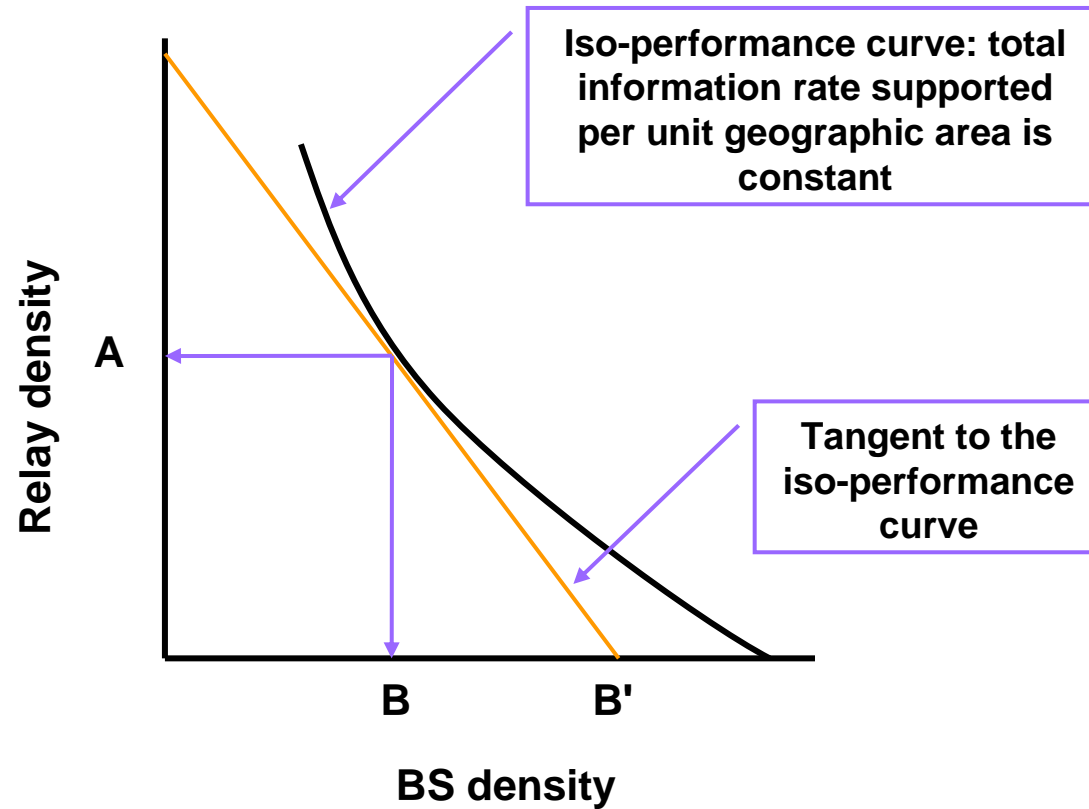


System capacity does not take account of any relays in the network

Graphical Description of “r” and “m”

$$m = \frac{A}{B}$$

$$r = \frac{A}{B' - B}$$



Spectral Efficiency

- **For a network operator, it is also desirable to minimise the total amount of spectrum used by the system to deliver a specified service. This is equivalent to maximising the spectral efficiency of the system**
- **Spectral efficiency is the effective system capacity per unit bandwidth**
- **Spectral efficiency is a useful “network-centric” or “operator-centric” metric. It is a maximum when the total amount of spectrum required to provide the required effective system capacity is a minimum**
- **Including spectral efficiency as part of the metric therefore provides a measure of both effective system capacity and the use of spectrum**

Recommended Metric

- **The recommended metric is therefore spectrum efficiency for a specified service at a particular level of coverage. It is described mathematically as follows:**

$$\eta = \frac{C_{eff}}{S}$$

$$= \frac{C}{S(1+m/r)}$$

for a specified service
at a particular coverage

where C_{eff} = effective system capacity

S = total spectrum used by the system

C = system capacity or total information rate per base station

m = number of relays per base station

r = ratio of the increase in the density of relays to the decrease in the density of base stations to maintain constant total information rate per unit geographic area

Typically $r \geq 1$ i.e., the relay density increases faster than the base station density decreases