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Glossary

Isotropic Radiator A theoretical source of electromagnetic waves which radiates the same intesity in all directions.. 7

Acronyms

EIRP Equivalent Isotropical Radiation Power. 7, 8

ICNIRP International Commission on Non-Ionizing Radiation Protection. 5

UABS Unmanned Arial Base Station. 6

1

Introduction

1.1 Outline of the issue

Society is constantly getting more dependent on electronic communication. On any given moment in any given location, an electronic device can request to connect to a bigger wireless medium. More and more devices need to be connected like IOT devices starting from small sensors up to self-driving cars.

Once again it becomes clear why we're on the eve of a new generation of cellular communication named 5G. This new technology is capable of handling millions of connections every square meter while satisfying only a few microseconds of a delay and providing connections up to 10Gbps [1].

Also in exceptional and possibly life-threatening situations, we rely on the cellular network. For example during the terrorist attacks in Zaventem, a Belgian city. Mobile network operators saw all telecommunications drastically increasing causing moments of contention. Some operators decided to temporarily exceed the limited exposure in order to handle all connections. [2]

Electromagnetic exposure can however not be neglected. Research shows how electromagnetic radiation can cause diverse biological side effects [3] and human exposure to these electromagnetic waves should be limited. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) suggests a limitation of 61 V/m. Also on national levels restrictions have been enforced but differ from location to location. In Brussels for example is a far more restrictive limitation enforced of 6 V/m for all sources [4, 5].

1.2 Objective

In order to provide a network, even if the existing network is damaged, a deployment tool has been developed by the UGent. The idea is to attach base stations to unmanned aircraft. Such a device is called an Unmanned Arial Base Station (UABS). The tool calculates where drones need to be positioned to connect an active user to the backbone network.

todo: several files, namelijk 4. This tool requires two input files. Firstly, a so-called shapefile of the disaster area describing the location of different buildings and their design. Secondly, the time period of the disaster is provided. The tool generates random users in different locations requiring certain bitrates.

Hereafter, the optimal locations for the different UABS are calculated. It is assumed that the entire existing network infrastructure down is and all active users, therefore, need to be reconnected.

The deployment tool does not calculate the electromagnetic exposure of the different active users in the area.

1.3 Structure

The following chapter 2 exists of several succesive sections explaining how the electromagnetic exposure of a single human being is calculated. The first section 2.1 explains how the exposure is calculated between a user and a single femtocell. Section 2.2 defines how to combine all exposures from the different femtocells towards a single users. Finaly, section 2.3 explains how directional antenna's are taken into account.

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State of the art

2.1 Calculating exposure

To determine the total exposure of a single human being or even of the entire network, the electric-field $\vec{E}$ of a single femtocell i should be calculated. The formula to determine this electromagnetic value E (expressed in V/m) for a specific location is given in equation 2.1.

$$E_i = 10^{\frac{EIRP-43.15+20*\log(f)-PL}{20}} \tag{2.1}$$

This formula requires several values to be known. The frequency f on which the tranmitting antenna is operating is expressed in MHz. The other values are explained in 2.1.1 and 2.1.2.

2.1.1 EIRP

A directional antenna can achieve gain by focussing it's input power into certain directions. By doing this, some areas experience a decreased radiation power in order to gain radiation power in the other privileged areas. If a theorical Isotropic Radiator existed, the Equivalent Isotropical Radiation Power (EIRP) is the power it would require to achieve the same power level as the actual antenna's main lob. The main lob is the area of the directional antenna experiencing the most gain. This EIRP value can be calulated as described in eq 2.2.

$$EIRP = P_t + G_t - L_t \tag{2.2}$$

This value is expressed in dBM and requires tree values. P_t is the transmit power (dBm), G_t is the gain (dBi) of the transmitting antenna and L_t stands for it's cable loss (dB) [6].

2.1.2 PL

At last, formula 2.2 requires the path loss (dB). In order calculate the path loss, an appropiate propagation model is required. Several propagation models exists and the tool already uses the Walfish-Ikegami model [7]. This is because the Walfish-Ikegami model performs well for femtocell networks in urban areas. The chosen propagation model consists of two formulas depending on whether a free line of sight between the user and the basestation exist or not. Both formulas expect a distance in kilometer.

2.2 Combining exposure

manets -> exosure combineren

$$E_{tot} = \sqrt{\sum_{i=1}^{n} E_i^2} \tag{2.3}$$

test

2.3 Radiation Patterns

waarom een ronde en waarom directional?

3 Deployment tool

Schrijf over hoe die exposure nu toegevoegd is aan de tool. -Wat deed de tool al? Users en femtocell's uniform verdelen op publiek transport, uabs etc - dat de exposure pas op het einde wordt berekend nadat het netwerk gemodeleerd is.

4

Scenarios

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