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       엘시스
<Oral Session>

발표장소 : B동 201호

1. 무선 및 정보기술

15:00-18:30

작 정 : 최 조 천 (목포해양대)

[1-1] 무선 메쉬네트워크에서 신뢰성 있는 IPTV 서비스를 위한 적응형 멀티캐스트 전환 기법 ................................................. 고석갑, 오승훈, 이병탁(한국전자통신연구원)

[1-2] SOP 기반 고속 양방향 광 송수신 모듈 ................................................................. 이종진, 임광섭, 이세형, 강현서, 고재성(한국전자통신연구원)

[1-3] ESM과 RADAR 센서 데이터 결합 기반의 단일표적 추적 시스템에 관한 시뮬레이션 구현......................................................... 김은찬, 박진태, 이재웅, 김기선, 김은로(광주과학기술원, 국방과학연구소)

[1-4] 시간 지연 파라미터를 고려한 TCP/RED 시스템의 안정도 분석 ............................................. 무석, 김기선(광주과학기술원)

[1-5] Mobile-to-Mobile 환경에서 Two-Ring MIMO 채널 모델 기반의 Wideband 다중Ring MIMO 채널 모델 ......................................................... 유수정, 김기선(광주과학기술원)

[1-6] 4G 통신시스템에서 Adaptive-MCM 기법을 이용한 전송률과 SNR간의 상호관계 개선................................................................. 조인식, 서창우, Sherlie P, 황인태(전남대학교)

[1-7] MIMO 시스템과 AMC 기법이 결합된 Adaptive-MCM 시스템의 성능 분석 ................................................................. 세월리 포루투갈, 서창우, 조인식 황인태 (전남대학교)

[1-8] 의미 특징과 워드넷을 이용한 문서요약 ................................................................. 박선, 김철원, 임석향 (전북대학교, 호남대학교, 전북대학교)

[1-9] 수중 정조 로봇을 위한 위치 추적 및 선수 응용지도 S/W 개발................................................................. 김갑기, 최승호, 김진영, 조성식 (목포해양대학교, 동신대학교, 전남대학교, 목포해양대학교)

[1-10] AtoN AIS에 의한 해양환경 정보전송 인터페이스 연구 ................................................................. 장철우, 차영호 최조천(목포해양대학교)
A Wideband Multiple-Ring MIMO Channel Model
based on Two-Ring MIMO Channel Models for Mobile-to-Mobile Communications

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Mobile-to-Mobile 환경에서 Two-Ring MIMO 체널 모델 기반의
Wideband 다중 Ring MIMO 체널 모델

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Abstract

This paper studies a geometrical channel model, a two-ring channel model, that exploits the wave propagation parameters to characterize a channel impulse response. We propose a multi-radius two ring MIMO channel model for wideband Mobile-to-Mobile (M-to-M) communications by considering differences of the propagation delays. In this model, the multiple-radius rings are considered around both of the transmitter and the receiver, and each ring has a different delay propagation delay, and this model satisfies the characteristic of the wideband MIMO channels.

I. Introduction

Mobile-to-Mobile (M-to-M) communications are recently researched due to their vast application potential in mobile ad-hoc wireless networks, intelligent transportation systems and relay-based cellular networks [1]-[2]. In contrast to the traditional Base-to-Mobile (B-to-M) cellular radio system where the base station is stationary, M-to-M communications cannot be free of local scattering because of the motion of the transmitter and the receiver. The movement of the mobiles causes a change of the location of the scatterers and a time variant channel. With these characteristics, there is a problem to use the existing channel models for cellular radio systems directly.

Early researchers studied M-to-M channel models for single-input single-output (SISO) systems [3], but recently MIMO channel models have emerged in M-to-M communications due to various advantages: diversity, reliability and efficiency. For proper MIMO M-to-M channel models, the influence of the measurements such as bandwidth, antenna array type and location of scatterers should be considered in practical, and considering a wideband (frequency-selective) characteristic is also in great need due to an increase of demands for high speed communications.

A geometrical two-ring model is one of the Geometry-Based Stochastic Models (GBSM) which generate the impulse response by using scatterer geometries chosen in a random manner. In [4], the authors derived a theoretical narrowband MIMO M-to-M facing channel from the geometrical two-ring scattering channel model considering the propagation environment around moving transmitter and receiver. However, although the narrowband models capture the characteristic by the motion of mobile, they neglect the propagation delay differences occurred in wideband transmission systems.

In this paper, we propose an extended traditional two ring model, a wideband multiple-ring MIMO channel model, to reflect the wideband MIMO M-to-M communication characteristics. The environment is rapidly changed by motion of the mobiles, and the different propagation delays occur due to the change of location of scatterers. The narrowband two-ring model just considers one radius respectively at the transmitter and the receiver, where the radius represents the average distance between each mobile and its scatterers. Therefore, there is no way to consider the time delay differences via the multipath. However, the proposed idea considers
the multiple radius rings at the transmitter and the receiver, so it is possible to describe the different propagation delays according to the different average distance between the mobile and the scatterers.

II. Wideband Multiple-Ring MIMO Channel Model

A. Review of the narrowband channel model

![Fig. 1. The narrowband two-ring MIMO channel model](image1)

A geometrical two ring model consists of the transmitter and the receiver which are in motion, and as shown in Fig. 2 the double-bounce scattering (two scatterers are randomly paired) is assumed [6]. Let us consider the transmitter and the receiver equipped $M_T$ transmit antennas and $M_R$ receive antennas respectively. $R_T$ and $R_R$ denote the average distance between each mobile and its respective scatterer, and it is assumed that the radius $R_T$ and $R_R$ are small in comparison to $D$ which is the distance between the origin of the transmitter and the receiver; i.e., $\max(R_T, R_R) < D$. The local scatterers $S_T^{(m)}$ ($m = 1, 2, \ldots, M$) lie on the ring around the transmitter with a radius $R_T$, and $S_R^{(n)}$ ($n = 1, 2, \ldots, N$) also lie on the second ring around the receiver with a radius $R_R$. The reference model has an assumption that the number of scatterers $M$ and $N$ is infinite. The value $\phi_T$ and $\phi_R$ represent the angle of departure (AOD) of the $m$th transmitted signal and the angle of arrival (AOA) of the $n$th received signal, respectively. The antenna spacings at the transmitter the receiver are denoted by $\delta_T$ and $\delta_R$, respectively. Generally the spacing $\delta_T$ and $\delta_R$ are much smaller than the radius $R_T$ and $R_R$, i.e., $\max(\delta_T, \delta_R) \ll \min(R_T, R_R)$.

The tilt angle between the $x$-axis and the direction of the antenna array at the transmitter is denoted by $\alpha_T$, and the tilt angle $\alpha_R$ also describes the angle about the direction of the antenna array at the receiver. Moreover, it is assumed that the transmitter (receiver) moves with speed $V_T$ and $V_R$ in the direction determined by the angle of motion $\beta_T$ and $\beta_R$, respectively. Finally, the rings of scatterers are assumed to be fixed, so that the mobile environment can be regarded as quasi-stationary for short periods of time $\Delta t \ll R_T/V_T$ ($\Delta t \ll R_R/V_R$).

Let us denote $h_{pq}(t)$ the time variant complex channel gain, which describes the link from $p$th transmit antenna ($p = 1, 2, \ldots, M_T$) to the $q$th receiver antenna ($q = 1, 2, \ldots, N_R$). In narrowband channels, $h_{pq}(t)$ is written as

$$h_{pq}(t) = \lim_{M \to \infty} \frac{1}{\sqrt{M N}} \sum_{m=1}^{M} \sum_{n=1}^{N} g_{mn} e^{j2\pi(f_{f,n} + f_{\delta,m} + \phi_{mn})}$$  \hspace{1cm} (1)

where

$$g_{mn} = a_m b_n c_{mn}$$ \hspace{2cm} (2)

$$a_m = e^{j(\phi_T \alpha_T - \phi_T)}$$ \hspace{2cm} (3)

$$b_n = e^{j(\phi_R \alpha_R - \phi_R)}$$ \hspace{2cm} (4)

$$c_{mn} = e^{j2\pi(R_{n} \cos(\phi_{mn} - \phi_{R}))}$$ \hspace{2cm} (5)

$$f_{f,n} = f_{\text{f},n} \cos(\phi_{mn} - \alpha_T)$$ \hspace{2cm} (6)

$$f_{\delta,m} = f_{\text{f},m} \cos(\phi_{mn} - \alpha_R)$$ \hspace{2cm} (7)

![Fig. 2. The proposed wideband multiple-ring MIMO channel model](image2)

The joint phase $\theta_{mn}$ are independent and identically distributed (i.i.d.) random variables, each having a uniform distribution over $[0, 2\pi]$.

B. A wideband multiple-ring MIMO channel model

From the narrowband channel in Fig. 2, we propose a wideband MIMO channel model, extended version of the traditional channel, by considering the multi-radius ring around the transmitter and the receiver. The proposed channel model is shown in Fig. 3, and we assume $K$ rings around the transmitter and $L$ rings around the receiver. In this model, all propagation delays are gathered together and divided to $K\cdot L$ discrete propagation delays and let us denote $\tau_{kl}$ as the propagation delay through the $k$th ring and the $l$th ring. The number of scatterers $M$ in the transmitter is assigned to $K$ paths ($M = M_1 + \ldots + M_K$), and the number of scatterers $N$ in the transmitter is assigned to $L$ paths ($N = N_1 + \ldots + N_L$). A signal
scattered on a ring means the signal via one path which have same characteristic such as same distribution and propagation delay. The different parameters compared with the narrowband reference model are $S_{T,k,m}$ ($k = 1,...,K$) and $S_{R,k,n}$ ($l = 1,...,L$) which represent a scatterer of the ‘$m$’th transmitted signal in ‘$k$’th ring in the transmitter and a scatter of the ‘$n$’th received signal in ‘$l$’ th ring in the receiver, respectively. The value $\phi_{T,k,m}$ and $\phi_{R,k,n}$ represent AOA of the ‘$m$’th transmitted signal in ‘$k$’th path at the transmitter and AOD of the ‘$n$’th scatter in ‘$l$’ th path at the receiver, respectively. The channel impulse response through the $k$ th ring and the $l$th ring between $p$ transmit antenna and $q$ receive antenna is expressed as

$$h_{pq,l}(t) = \lim_{N \to \infty} \frac{1}{MN} \sum_{\nu=1}^{\nu_r} \sum_{b=1}^{b_r} g_{\nu,b,\nu_0} e^{j2\pi(f_{\nu,b} t + \phi_{\nu,b,l} + \theta_{\nu,b,l})}$$

where $g_{\nu,b,\nu_0} = g_{\nu,b,\nu_0}(\phi_{\nu,b,l}, \phi_{\nu,b,l}, \alpha_{\nu,b,l}, \nu, \nu_0)$.

As illustrated in Fig. 3, the scatterers are partitioned into $K$ and $L$ paths, and there should be different propagation delays according to the different path. The minimum and maximum propagation delays are expressed by $\tau_{\nu,b,l} = \frac{D}{c_0}$ and $\tau_{\nu,b,l} = \frac{D+2R+2R_i}{c_0}$, where $c_0$ is the speed of light. The average propagation delay for each ring is defined as

$$\tau_{\nu,b,l} = \frac{\tau_{\nu,b,l}^{\min} + \tau_{\nu,b,l}^{\max}}{2} = \tau_{\nu,b,l}^{\min} + \frac{R_s + R_i}{c_0}.$$  

If the micro propagation delays are neglected compared with the macro propagation delays, all the scatterers on the same ring are assigned to one propagation delay. Therefore, the propagation delay for each ring is same as the average propagation delay: i.e., $\tau_{\nu,b,l} = \bar{\tau}_{\nu,b,l}$. As a result, the impulse response of wideband MIMO channel is expressed as

$$h_{pq,l}(t) = \sum_{k=1}^{K} \sum_{l=1}^{L} h_{pq,l}(t) \delta(t - \tau_{kl}).$$  

### III. Conclusion

This paper provides a wideband MIMO channel model by considering the multiple-radius rings around the transmitter and the receiver, respectively, to satisfy an increase of demands for high speed communications. In the wideband channels, the differences of the propagation delays cannot be ignored, so the proposed model assign the different propagation delay to each ring and then it can consider differences of the propagation delays.

### Acknowledgment

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### References


