

Electronic Tracking for Wireless Infrared Communications

Volker Jungnickel, *Member, IEEE*, Andreas Forck, Thomas Haustein, Udo Krüger, *Member, IEEE*, Volker Pohl, and Clemens von Helmolt

Abstract—A high-speed wireless system (≥ 100 Mb/s) for indoor infrared (IR) communications via the line of sight is described and feasibility is shown in an experimental demonstration. A diffuse link is used for connectivity, and tracked directed links are used for high-speed communications.

The transmitter is made of a laser diode array in combination with multiple-beam forming optics. For the receiver (Rx), a wide-angle lens, and an avalanche photodiode array are used. For the diffuse link, the signals from all pixels in the array are combined. Pixels are selectively addressed to realize directed links. Fast electronic tracking of a directed link is possible by switching the signal path onto the right pixel in the array. Diffuse link, directed link, position detection, and tracking can be realized with one and the same transceiver hardware.

A favorite system design is derived from constraints due to the IR channel, eye safety, lenses, photodetectors, and the overall system complexity. The experimental system shows some key features, namely 155-Mb/s wireless transmission over a distance of nearly 2 m with electronic tracking at an imaging IR Rx. Electronic tracking of IR links, thus, allows both high data rates and high capacity for wireless access in small office and home environments.

Index Terms—Beam steering, directions of arrival (DOA) estimation, multiaccess communication, multipath channels, optical arrays, optical communication, wireless local area network (WLAN).

I. INTRODUCTION

AT PRESENT, people are familiar with wireless communication systems and much research is done to increase their data rate and capacity. At the same time, a public discussion rises whether or not microwave radiation has nonthermal effects on human tissue in addition to the well-known heating process due to absorption. The present paper is intended to evaluate the potential of infrared (IR) transmission as an alternative to radio for applications in wireless local area networks (WLANs). The basic properties of IR WLANs were investigated in [1]. While the diffuse configuration was studied in detail in [2], the present paper is mainly concerned with the tracked directed link architecture.

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The authors are with Fraunhofer Institute for Telecommunications, Heinrich-Hertz Institute, D-10587 Berlin, Germany (e-mail: jungnickel@fhz.de).

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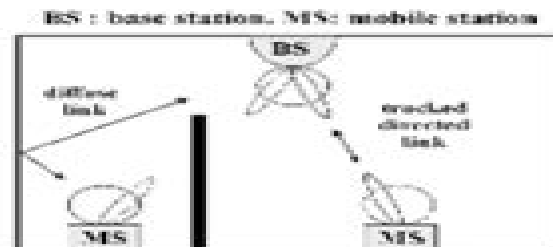


Fig. 1. Two basic link modes for wireless IR communications. The diffuse link is based on reflections at the walls, the ceiling, and the floor and, in principle, no LOS is required. When the LOS is free, a tracked directed link is preferable. It is more power-efficient and allows data rates beyond 100 Mb/s.

At first sight, it seems to be difficult to support mobility of the user with a directed optical link. For instance, the popular Infrared Data Association interfaces must be carefully aligned to each other and the maximum distance is about 1 m. In contrast, a diffuse IR link offers better mobility since it uses diffuse reflections from the walls, the ceiling, and the floor (see Fig. 1) to transmit data from an IR transmitter (Tx) to an IR receiver (Rx) and, hence, no alignment is required. Connectivity between Tx and Rx can be maintained even when the line of sight (LOS) is blocked. On the other hand, the signal arrives with a delay spread of some ten nanoseconds at the Rx and, in unfavorable configurations, a transmission bandwidth of less than 10 MHz may be available [3]. In addition, the entire room must be illuminated by the Tx. This is naturally realized by diffuse light propagation after a few reflections but it needs a huge Tx power. For instance, 475 mW Tx power was needed for a diffuse 50-Mb/s link at 4.4-m horizontal separation between Tx and Rx, both directed to the ceiling [2].

Tracked directed links are a different concept, also shown in Fig. 1. The base station (BS) is mounted at the ceiling and the mobile stations (MSs) are placed on table-top height. Both in the up-link and in the down-link, the Tx beam is concentrated onto the Rx and less power is needed than in a diffuse link. Both the narrow Tx beam and the smaller field of view (FOV) of the Rx reduce multipath signals due to diffuse reflections, and a high bandwidth becomes available. Additionally, interference by the sun or artificial light sources can efficiently be suppressed by pointing a directive Rx selectively toward the Tx. A manually tracked directed IR link with 155 Mb/s over a distance of 2 m was demonstrated in [4] and a 1-Gb/s link was reported in [5].

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Low-Power Wireless Infrared Communications Rob Otte, Leo P. de Jong, Arthur H.M. van Roermund, 2013-04-17 Today wireless infrared transmission has entered our homes offices industry and health care with applications in the field of remote control telemetry and local communication This book is about the underlying technology As it is an outgrowth of my Ph D thesis the emphasis is on fundamental aspects rather than industrial aspects like the standardization effort by the IrDA 7 I guess that this is not a drawback as eventually the laws of physics apply to all of us As the applied radiation is not necessarily in the infrared throughout the book we usually prefer the term optical transmission As most equipment is battery powered the emphasis is on power optimization of the optical transmission system System parameters as well as environmental parameters that determine the eventual transmission quality are identified to facilitate well reasoned system design Many design rules based on calculations measurements and simulations are presented to help the designer push the performance close to the limits set by nature and the available technology The first chapters introduce the subject and the present the scope of the book Then the basic transmission link is introduced in chapter 3 and strategies to optimize its signal to noise ratio are discussed Lighting flicker is identified as a possible source of interference Then receiver noise and bandwidth are discussed in chapter 4 mainly based on the material presented in 66 67 69

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Table of Contents Wireless Infrared Communications Wireless Infrared Communications

1. Understanding the eBook Wireless Infrared Communications Wireless Infrared Communications
 - The Rise of Digital Reading Wireless Infrared Communications Wireless Infrared Communications
 - Advantages of eBooks Over Traditional Books
2. Identifying Wireless Infrared Communications Wireless Infrared Communications
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Wireless Infrared Communications Wireless Infrared Communications

- User-Friendly Interface
- 4. Exploring eBook Recommendations from Wireless Infrared Communications Wireless Infrared Communications
 - Personalized Recommendations
 - Wireless Infrared Communications Wireless Infrared Communications User Reviews and Ratings
 - Wireless Infrared Communications Wireless Infrared Communications and Bestseller Lists
- 5. Accessing Wireless Infrared Communications Wireless Infrared Communications Free and Paid eBooks
 - Wireless Infrared Communications Wireless Infrared Communications Public Domain eBooks
 - Wireless Infrared Communications Wireless Infrared Communications eBook Subscription Services
 - Wireless Infrared Communications Wireless Infrared Communications Budget-Friendly Options
- 6. Navigating Wireless Infrared Communications Wireless Infrared Communications eBook Formats
 - ePub, PDF, MOBI, and More
 - Wireless Infrared Communications Wireless Infrared Communications Compatibility with Devices
 - Wireless Infrared Communications Wireless Infrared Communications Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Wireless Infrared Communications Wireless Infrared Communications
 - Highlighting and Note-Taking Wireless Infrared Communications Wireless Infrared Communications
 - Interactive Elements Wireless Infrared Communications Wireless Infrared Communications
- 8. Staying Engaged with Wireless Infrared Communications Wireless Infrared Communications
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Wireless Infrared Communications Wireless Infrared Communications
- 9. Balancing eBooks and Physical Books Wireless Infrared Communications Wireless Infrared Communications
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Wireless Infrared Communications Wireless Infrared Communications
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Wireless Infrared Communications Wireless Infrared Communications
 - Setting Reading Goals Wireless Infrared Communications Wireless Infrared Communications

- Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Wireless Infrared Communications Wireless Infrared Communications
 - Fact-Checking eBook Content of Wireless Infrared Communications Wireless Infrared Communications
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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