Handoff in Radio over Fiber Indoor Networks at 60 GHz

Van Quang Bien, R.Venkatesha Prasad and Ignas Niemegeers
Electrical Engineering, Mathematics, Computer Science Faculty, Delft University of Technology
Mekelweg 4, 2628 CD, Delft, The Netherlands
{*v.q.bien,rprasad,i.g.m.m.niemegeers*}*@tudelft.nl*

Abstract

Wireless indoor networks employing Radio over Fiber technique combining 60 GHz wireless networks with wired networks is a new solution to provide high definition in-home multimedia applications. About 5 Gbps is available around 60 GHz band. In 60 GHz band each antenna can cover a small space such as a single room in a building. Thus more antennas are needed to cover the whole building. This leads to frequent handoffs. In addition, the overlapping between two adjacent cells is normally small; therefore a handoff should be completely done in a relatively shorter time compared to cellular networks. Since there are many research results and commercial systems for wireless indoor positioning, predicting the direction of the movement of a user is very easy. This paper proposes the direction assisted handoff algorithm. The simulation results show that the proposed handoff algorithm can reduce the total number of handoffs while increasing the percentage of successful handoffs.

1 Introduction

Recently, demand for broadband multimedia services has increased personally as well as commercially. In the near future, the home and office networking environments are predicted to be dominated by a variety of multimedia services like wireless HDTV, wireless home entertainment and virtual wireless office. These services require wireless communication to provide the data rate of over 1 Gbps. In order to provide high bandwidth for these applications, many studies of new air interfaces have been proposed. Worldwide availability of spectra around 60 GHz (57 – 66 GHz), which permits many broadband applications with 7 GHz of license exempt spectrum, is an obvious candidate for the PHY layer of broadband wireless networks. While the available spectrum of IEEE 802.11n and UWB are 660 MHz and 1.5 GHz, respectively. In addition, 60 GHz can offer 2,500 MHz of spectrum per channel, also referred to as bandwidth, while UWB has just 520 MHz and 802.11n has only 40 MHz. Table 1 also shows that 60 GHz is able to achieve 80 times the maximum possible data rate of 802.11n and 200 times that of UWB [1].

Due to high attenuation 60 GHz band in propagation, it is mainly envisaged to accommodate short-range gigabit wireless networks, such as WPANs and WLANs. In indoor environments, obstacles like furniture, wall can take a significant amount of the channel budget (20 – 30 dB). The range of an antenna is usually less than 25 m in the open area. However in indoor environment, each antenna acts as an Access Point (AP) and can cover only a single room. Thus a large number of antennas are required

Table 1: Technical comparison of 60 GHz, IEEE 802.11n, and UWB

Techniques	Available spectrum	Channel bandwidth	Data rate	Global availability
60 GHz	7 GHz	2,500 MHz	25,000 Mbps	Y
IEEE 802.11n	660 MHz	40 MHz	1,100 Mbps	Y
UWB	1.5 GHz	520 MHz	80 Mbps	N

[0]This paper is extended from the paper "A direction assisted handoff algorithm for Radio over Fiber Indoor Networks at 60 GHz" in MoMoPE 2010

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to cover whole a building and is very expensive. In order to deploy widely the 60 GHz band in indoor environment, it is necessary to reduce the cost of the infrastructure by simplifying the complexity of the APs.

To do this, the indoor network using Radio over Fiber technique at 60 GHz (termed as RoF network) has been proposed [2]. The typical architecture of the RoF network is illustrated in Fig. 1 which consists of three components: APs which are simple antennas (AT), an optical distribution network, and a central control unit called Home Communication Controller (HCC). By combining wireless and wired networks, a large part of complex functionality of traditional APs such as signal processing unit could be transferred to the HCC.

Handoff is an important aspect in wireless and cellular communication due to the mobility of devices. It is a critical problem in the 60 GHz system. A simple comparison between 60 GHz band and the popular wireless communication bands, say GSM 1800 MHz, shows that the wavelength of 60 GHz is 30 times less than that of the GSM. Comparatively a mobile user here will be moving very fast at 5 mm wavelength [3]. For example a person moving at 1 m/s in 60 GHz network is similar to the user moving with a speed of 108 km/h in GSM environment. Thus handoff in the 60 GHz band is worse than that at low frequencies since the users move too fast with respect to the wavelength. In addition, the small coverage of each AP is mainly dependent on the surrounding objects such as walls, doors, furniture, etc. The overlapping area between two adjacent cells is also small. These conditions make a handoff occur frequently and should be completed in a short time.

Fortunately, there are many research results and several commercial wireless indoor positioning systems have been proposed (see more detail in [4]). There are two main approaches of indoor positioning systems: i) use of existing radio frequency infrastructures such as WLAN, Bluetooth, and ii) installation of specialized indoor positioning systems. Methods in the first category are more economical, but have low accuracy and low degree of precision due to signal instability, noise from hardware and environmental factors like human in motion. The second category can localize the a mobile user with high accuracy and high precision, for example Ubisense [5] has 99% precision within 0.3 m, but it requires high cost for large scale deployment. This paper proposes the handoff algorithm using the motion direction of a mobile station (MS). The proposed algorithm can be improved significantly in terms of reducing the number of handoffs while increasing the number of successful handoffs.

Rest of the paper is organized as follows: Section 2 lists some related work. The proposed direction assisted handoff algorithm is presented in Section 3. The simulation results are discussed in Section 4. Section 5 concludes the paper.

2 Related Work

In recent years, a few works on handoff in the 60 GHz band are proposed. In [6], a MAC scheme is presented to reduce the handoff delay. This protocol is based on frequency switching codes. The bandwidth is divided into $2M$ channels where M channels are used for uplink transmission and the other M channels are used for downlink transmission. Every BS supports all channels. To request permission for uplink transmission on a channel, the MS sends a request to the control station using the reservation field in any slot in this channel. The analysis in [6] shows that the proposed MAC scheme can support QoS requirements and make a fast and easy handoff. The proposed MAC scheme can also be used for indoor and outdoor communication at 60 GHz.

In [9], an innovative architecture called Virtual Cellular Network is proposed. The architecture uses the ideas of Single Frequency Network and distributed APs to form an adaptive wireless architecture. A virtual cell (VC) is formed dynamically for each and every MS. Because the network operates at a single frequency and a VC is always to follow an MS, there is no conventional handoff. Each time the MS moves to a new position, a new VC is created and the routing table should be updated in the system. The drawback of the proposed architecture is that the whole spectrum must be shared with a large number of users.

In [8], the Extended Cell (EC) concept is proposed in the multi-channel system like RoF network. ECs are dynamically created by grouping several adjacent cells. The proposed architecture can help in enlarging the overlapping area between two adjacent cells in RoF indoor networks. So the handoff performance is improved. The simulation results show that the number of handoffs is reduced significantly and the probability of a call drop during handoff for while using EC is up to 70% less compared to the case when EC is not used.

Another work proposed for communication in trains is to use 60 GHz with a novel concept of Moving Cell [7]. If a 100 m train moves with a speed of 100 km/h, handoff is carried out frequently with a period of 1 s. By utilizing the advantage of RoF techniques, the cells will move together with the train to provide broadband Internet to passengers. By that mechanism, the system can avoid the most of handoffs. Unfortunately, this concept might not be applicable for indoor environments where a large number of users move in different directions.

The concept Moving Extended Cell (MEC) proposed in [10] for Radio over Fiber networks may gain benefits of the above three concepts – EC and MC and VC. An EC is formed by 7 adjacent cells and the data emission frequency is the same in every single cell. Each user has been covered by the 7-cell EC which moves together with the user. The simulation results show the proposed architecture can achieve almost 0% call drop and no packet loss for mobile speeds up to 40 m/s and mitigate the corner effect phenomena [8]. The authors suggest that Radio over Fiber network at 60 GHz can apply for both indoor pedestrian communication as well as vehicular communication. However, the three concepts mentioned above need to be properly defined as to when and how the algorithms should run to create them dynamically, if we need to apply them to multiple MS scenarios.

Due to the vulnerable nature of 60 GHz LOS links, vertical handoff from 60 GHz radio to WLAN is the proposed solution to overcome that feature [11]. The handoff decision algorithm is designed as cognitive approach and based on decision theory with multiple factors such as, user preference, network condition, the capacity of the terminals, etc. The proposed decision theory based algorithm is compared to three naive algorithms: i) algorithm "r" that chooses randomly networks, ii) algorithm "s" that always switches to WLAN when LOS is blocked, and iii) algorithm "w" that always waits for 60 GHz recovery. The simulation results show the proposed algorithm is able to make a handoff in uncertain situations.

In cellular wireless networks, the direction biased handoff algorithm is proposed [12], in which the base stations (BS) are divided into two groups: (1) Approaching group A includes all BSs that the mobile user approaches to; (2) Receding Group R includes all BSs that the mobile user moves away. To encourage a mobile user making handoff to a BS in Group A, the algorithm introduces hysteresis values h_e and h_d for A and R, respectively, where $h_e \leq h \leq h_d$. The simulation result shows that the proposed algorithm improves handoff performance by lowering the mean number of handoffs while reducing the handoff delay. Different from the previous works, we do not change the architecture of the RoF network; we try to improve the performance of handoff algorithms with additional information such as moving direction of an MS.

3 The Proposed Direction Assisted Handoff Algorithm

3.1 Handoff in the RoF network

Handoff is the process that maintains a call of an MS while it is moving in and out of the coverage area of different cells. It does so by changing the current channel in the current cell into a new channel, when the MS moves into a new cell. In general, a handoff procedure has three phases: i) the measurement

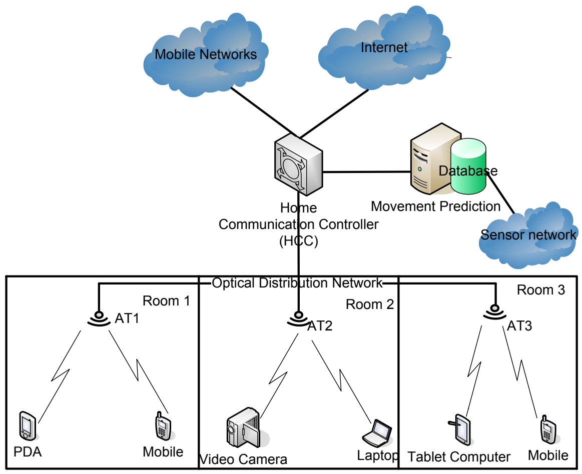


Figure 1: The proposed architecture of the RoF network

phase, ii) the handoff decision, and iii) the handoff execution in which the new channel will be assigned to the MS and the old connection will be terminated. Handoff process is usually carried out in the overlapping area between two adjacent cells. In [13], the authors state that handoff depends on cell size, the overlapping area and signaling delay through the probability of handoff failure is given below [13].

$$p_f = \begin{cases} 1 & \tau > \frac{\sqrt{\frac{r^2}{4}+d^2}}{v} \\ \frac{1}{\theta_1} arccos(\frac{d}{v\tau}) & \frac{d}{v} < \tau \leq \frac{\sqrt{\frac{r^2}{4}+d^2}}{v} \\ 0 & \frac{d}{v} \geq \tau \end{cases} \quad (1)$$

where p_f if the probability of handoff failure, τ is the signaling delay, d is the distance of the overlapping area, r is the diameter of the cell, θ_1 is the direction of motion of the MS and v is the velocity of the user.

Handoffs in the RoF network can be affected by three parameters: the cell size, the signal strength, and the overlapping area. First, the 60 GHz cell size is much smaller than the coverage of the GSM cell due to high propagation attenuation. Assuming that an antenna has a height of 3 m, transmitted power of 15 dB, the range of the antenna is approximately 25 m in an open space. In indoor environment, the cell size is even smaller when each antenna can cover only a single room (10×10 m). Thus handoff occurs more frequently. The high frequency of handoff leads to an increase in the probability of a call drop. For example, a user moves with an average speed of 2 m/s, a handoff has to be carried out every 5 s. Second, the transmission of the 60 GHz signal is severely affected by shadowing. Obstacles like furniture and even a person can completely block the signal. SIR can drop significantly almost by 20–30 dB [16] and rise up to 20 dB in a few centimeters. In this case, a fast handoff is not suitable. So handoff algorithm should deal with the fluctuations of the signal strength. Third, the overlapping area is also small because of the small cell size. In indoor environment, the overlapping area is narrow and directional when it is usually formed in open areas like doors and windows. Overlapping area might be too small to offer the MS sufficient time to complete the handoff if not identified early enough. Thus in order to improve a handoff algorithm in the RoF network, one can enlarge the overlapping areas, and/or the cell size, and/or improve the handoff signaling delay τ. The proposed direction assisted handoff algorithm can improve τ and deal with a fast change in SIR.

Table 2: Antenna with its corresponding wavelengths

Antenna ID	Downlink	Uplink
AT_i	λ_{DLl}	λ_{UPl}
AT_j	λ_{DLk}	λ_{UPk}

Table 3: The geographical information table of antennas

Antenna ID	X axis	Y axis	Height	Geographical Info.
AT_i	$AT_i[x]$	$AT_i[y]$	h_i	$Room_l$
AT_j	$AT_j[x]$	$AT_j[y]$	h_j	$Room_m$
AT_k	$AT_k[x]$	$AT_k[y]$	h_k	$Common\,Room_v$
AT_l	$AT_l[x]$	$AT_l[y]$	h_l	$Common\,Room_v$
AT_m	$AT_m[x]$	$AT_m[y]$	h_m	$Corridor$

Table 4: The address table of an MS and its corresponding antenna

Antenna ID	MS address
AT_i	MS_q
AT_i	MS_p
AT_j	MS_o

3.2 The Proposed System Architecture

Fig. 1 illustrates the system architecture to support the proposed handoff algorithm. In this architecture, each antenna has its own identification number (AT_i). Since the optical distribution network uses WDM, at least one pair of wavelength for the uplink (λ_{UPl}) and the downlink (λ_{DLl}) is fed to each antenna. The antenna information and its corresponding wavelengths are stored and maintained by the HCC in Table 2. In addition, each antenna is usually located in the suitable place in the building such as mid spot in a room or the corridor. Table 3 stored in the HCC includes the antenna's coordinates, and the place it is located in. This table is separated from Table 2 due to the reason that wavelengths of each antenna could change and each antenna could have more than one pair of wavelengths.

Each MS has its own unique address (MS_q). To communicate with other MS and to fix the location of the MS, HCC has to update the table containing the address of the MS and the corresponding antenna to which the MS is connecting to (Table 4). The coordinates of each MS are stored and updated in the database in the server as shown in Fig. 1.

A positioning system and a moving prediction algorithm are used additionally. The sensor network is playing the role of an indoor positioning system. The movement information of an MS is periodically collected and stored in a server. The HCC can find position of a mobile user in the server. Following [4], there are several positioning systems and they can be classified into two classes: i) utilizing the existing system such as WLAN and ii) installation of special positioning systems. The systems in the first category are more economical but have low accuracy and degree of precision. On the other hand, the commercial systems in the second category can localize the user with high precision degree. We can use commercial positioning systems such as Ubisense with a high degree of precision and accuracy of 50 cm. Assuming there is a prediction algorithm performed in the server. This algorithm processes the historical location information of an MS to predict next location of the MS.

As illustrated in Fig. 2, the prediction of location of the MS is the point MS' in the ideal condition. If the error range of the predicted moving direction is θ, the location of the MS will be somewhere

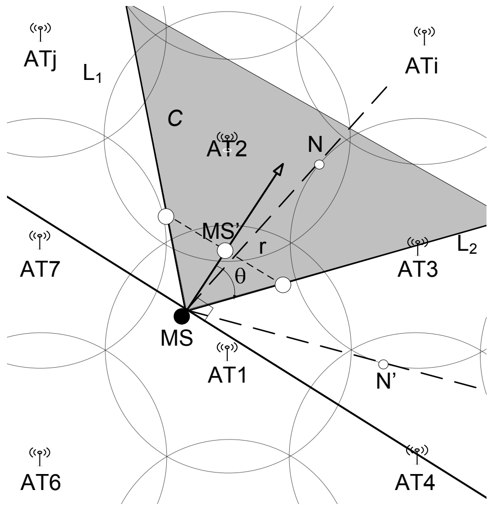


Figure 2: The potential antennas from the moving direction of the MS

else within the coverage area C between two lines L_1 and L_2 (the grey part in Fig. 2), where the angles between the actual direction of the MS and L_1 and L_2 are $\pm\theta$. In the worst case, when the movement of MS is completely random, θ is 90^o.

3.3 The Proposed Handoff Algorithm

In this section, the direction assisted handoff algorithm is proposed. At first, handoffs are controlled by MSs with the assistance of the HCC. We can divide each cell into three areas: serving area, handoff preparation area, and handoff area. If the HCC or an MS can define the area the MS is within, the handoff request can be performed accurately and timely. In addition, there are several antennas located around the building to cover the whole building. Several candidate antennas can provide the MS with good signals. Thus it takes time for the MS to scan all adjacent antennas to choose the best one. By using the moving direction of the MS, it is possible to define which antenna the MS goes towards next time. In ideal conditions, the MS could choose exactly the expected target antenna. However, the mobility of the MS is usually unstable and hence the predicted direction may have an error range as mentioned above. Thus the MS should select a set of antennas which has the overlap with the coverage C (Fig. 2). The antenna AT_i has the overlap with the C if one of two junction points N, N' of two tangents from the point MS with the coverage of AT_i is within the C. The coordinates (x,y) of N and N' can be achieved through the set of equations 2, (x_{MS}, y_{MS}) are the coordinates of the MS, (x_i, y_i) are the coordinates of AT_i, and a is the radius of the coverage of AT_i. The point N is in C if $\theta_1 + \theta_2 = 2\theta$, where θ_1, θ_2 are the angles between the line through two points N, MS and L_1, and L_2, respectively.

$$\begin{cases} (x_{MS}-x)^2+(y_{MS}-y)^2=(x_{MS}-x_i)^2+(y_{MS}-y_i)^2-a^2 \\ (x_i-x)^2+(y_i-y)^2=a^2 \end{cases} \tag{2}$$

Assuming that set S consists of all n candidate antennas for the MS, $S=\{AT_i\}$, with $i=1,...,n$, by using the moving direction, the MS can select a subset of the set S consisting of m approaching antennas A based on two conditions: (i) belongs to the set S, and (ii) having the overlap with the coverage C. Set A is given as: $A=\{AT_j\}$, where $i=1,...,m$, $AT_j \in S$, and $m \le n$. For example, in Fig. 2, S includes AT_i, for $i=2,...7$, in which AT_2 and AT_3 are two approaching antennas for the MS. The following algorithm is used by HCC to select an antenna for set A:

Algorithm 1 (searching Approaching Antennas)**.**

i: integer $\{$*the antenna to which the MS currently connected*$\}$
N: set of integers $\{$*neighboring antennas of the antenna i*$\}$
A: set of integer init ϕ $\{$*set of the approaching antennas*$\}$
C: $\{$*coverage between two lines from MS' location*$\}$
for all $j \in N$
  find N, N'*;*
  if N *in* C *or* N' *in* C
    $A := A \cup j$;
  end if
end for

The MS samples the received power from the current antenna every Δt times. Thus θ can be calculated as, $\theta = \arccos(\frac{r}{v\Delta t})$, where r is the error range of the direction prediction algorithm, and v is the speed of the MS. Whenever the signal strength of the current antenna is below the threshold (in the handoff preparation area), the MS requires the set of approaching antennas from the HCC and makes a handoff decision. If no antenna in A is selected, the candidate antenna is chosen from the remaining antennas in S. The handoff algorithm is proposed as follows:

Algorithm 2 (The proposed handoff algorithm)**.**

i: integer $\{$*the antenna to which the MS currently connected*$\}$
A: set of integer init ϕ $\{$*set of the approaching antennas*$\}$
RSS_{cur}*: double* $\{$*signal strength of the current antenna*$\}$
if$(RSS_{cur} \leq Thres_1)$
  do Algorithm 1;
  for all $j \in A$
      measure RSS_{ij} *from* AT_j*;*
  end for
  if$(RSS_{cur} + h) \leq RSS_{ij}$
    handoff to AT_j*;*
  end if
end if
if *no handoff*
  for all $j \in S$ *and* $j \notin A$
    measure RSS_{ij} *from* AT_j*;*
    if$(RSS_{cur} + h') \leq RSS_{ij}$
      handoff to AT_j*;*
    end if
  end for
end if

4 Simulation and Results

4.1 Simulation Setup

To evaluate the effectiveness of the proposed algorithm, a simulation of RoF indoor network has been developed in C++. Fig. 3 illustrates a top-view of an office building that is used in our simulation. In

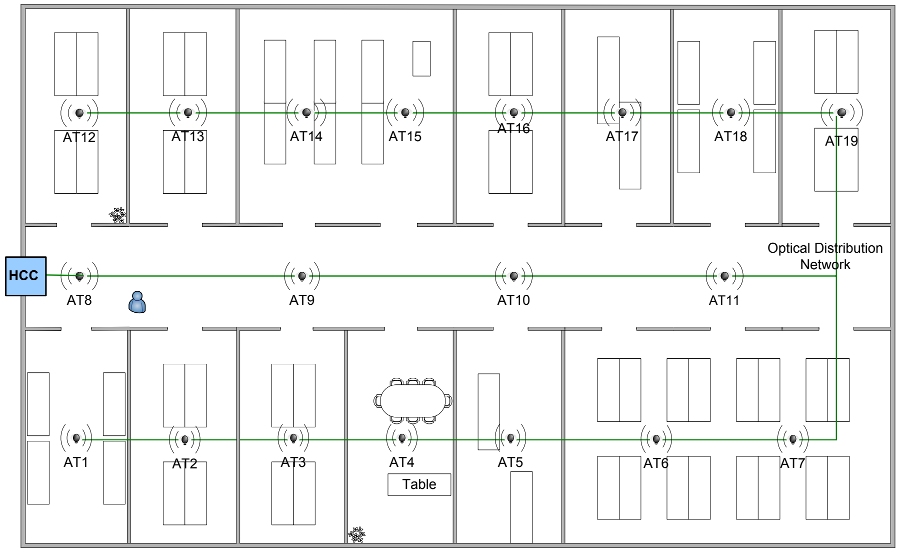


Figure 3: The floor plan using in the simulation

each room, an antenna is located to cover the whole room. With a common room, there are two antennas. In a corridor, antennas are located at a distance of 10 m. Tables are modeled as rectangles that can affect the mobility of the user. The user mobility is modeled using Random Walk Mobility Model with reflection [15]. In order to understand the effect of the mobile speed on the performance of handoff algorithm, there is a small change in the mobility model: in each simulation the speed of mobile user is fixed within the range 0.25 m/s to 2 m/s. The MS samples the received power every Δt = 50 ms. The transmitted power of each antenna is 15 dBm. The gain of transmitter and receiver is set to 0 dB.

The propagation model investigated is: Friis model and multi-ray propagation model. In multi-ray propagation model, many components such as single reflected component and double reflected component are included. In order to simplify the simulation and reduce the calculation time, two-ray propagation model is chosen, given by,

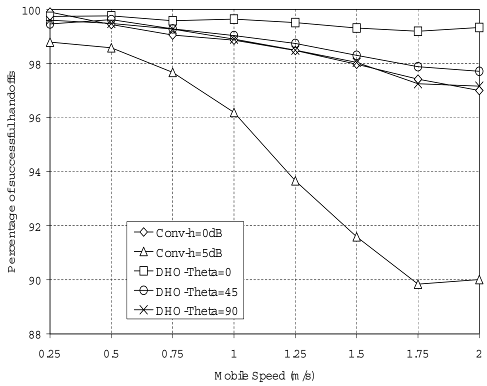
$$P_r(d) = P_t + G_t + G_r - L_p(d) \tag{3}$$

where, the path loss in the indoor environment is calculated as Eq.4 [14]:

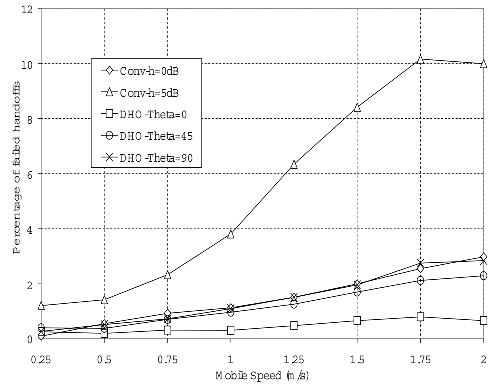
$$L_p(d) = 68 + 20log\left(\left|\frac{1}{d_0} + \frac{r_i}{d_i}e^j\Delta\phi_i\right|\right) \tag{4}$$

where, d is the distance between the transmitted antenna and the mobile user; d_0 is the path length of the direct component; d_i is the path length of the floor reflected ray; r_i is the reflection coefficient of the floor surface ≈ 1.

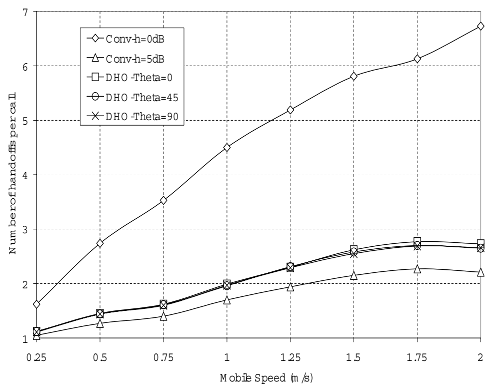
The following parameters are measured during the simulation: number of initiation of handoffs, failed handoff, false initiation of handoff, successful handoff, ping-pong and outage. The initiation of handoff parameter represents the number of times a handoff is requested. When a handoff is completed, the location of an MS is checked. If the location of the MS is in both the old and the new antenna, a handoff is successful. If the location of the MS is in the old antenna but not in the new antenna, it is called initiation failed handoff. Otherwise, the location of the MS is out of the old antenna, a handoff is failed. Two consequent handoffs between two antennas within the given ping-pong time $t_{ping-pong}$ are considered as ping-pongs. The $t_{ping-pong}$ is calculated as the time required for the MS to come across the overlap between these two adjacent antennas. Outage is also monitored in this simulation. Amongst all mentioned parameters, failed handoff and outage can cause a call drop and other two parameters,



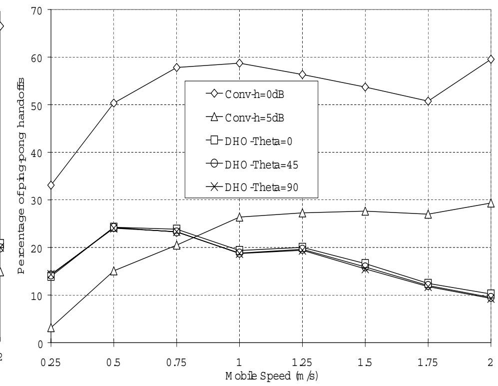
(a) The percentage of successful handoffs



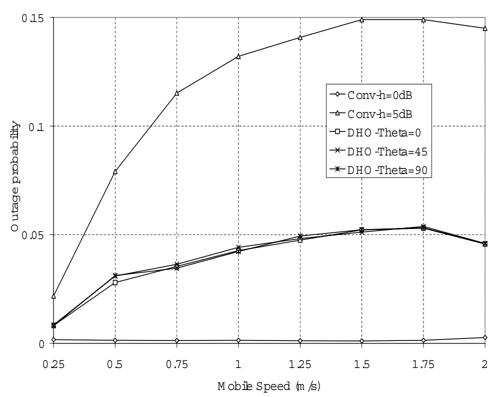
(b) The percentage of failed handoffs



(c) The number of handoffs per call



(d) The percentage of ping-pong handoffs



(e) The outage probability

Figure 4: Simulation Results

initiation failed handoff and ping-pong handoff could increase overhead load and make the probability of call drop higher.

The proposed handoff algorithm is evaluated with three cases of the corresponding error in prediction algorithm, θ: i) the ideal condition: $\theta = 0^o$, ii) $\theta = 45^o$, and iii) the worst case: $\theta = 90^o$.

4.2 Results

There are a small number of false initiation handoffs for every handoff algorithm studied in our simulation. Thus the percentage of successful handoffs, the percentage of failed handoffs, the percentage of ping-pong, the number of handoffs per call, and the outage probability are determined based on the measured parameters. In Fig. 4(a), the number of successful handoffs sinks significantly when the hysteresis is from 0 dB to 5 dB. When the speed of the mobile user is 0.25 m/s, this is 99%, 98%, respectively. In case the mobile user speed of 2 m/s, there is a huge difference, 95% to 87%, respectively. Thus handoff in 60 GHz needs an adaptive hysteresis with the mobile speed. With the direction assisted handoff algorithm (DHO) it is above 99% when the mobile speed is between 0.25 m/s to 2 m/s. In the worst case, it is slightly higher than that of conventional handoff when no hysteresis (conv-h = 0 dB) is used.

In Fig. 4(b), the percentage of failed handoff of the conventional handoff with hysteresis of 5 dB (conv-h = 5 dB) is worst, it goes up to 10% at two speeds of the mobile, 1.75 m/s and 2 m/s. Meanwhile, the percentage of failed handoff of DHO is less than 1% in case of $\theta = 0^o$. Even in the worst case, $\theta = 90^o$, its performance is slightly better than that of the conv-h = 0 dB. This is due to the proposed algorithm might save time by scanning only candidate antennas.

The unnecessary handoffs can be limited by using the hysteresis. Conventional handoff algorithms make a trade-off between the number of handoffs and the handoff delay. In Fig. 4(c) and Fig. 4(d) the number of unnecessary handoffs decrease significantly when the hysteresis is 5 dB. Comparing this parameter in case of no hysteresis, the number of handoff per call in case of the conv-h = 5 dB is smaller than that of conv-h = 0 dB with the mobile speed being in the range 0.25 m/s to 2 m/s. In case the mobile speed is 2 m/s, the conv-h=0 dB has nearly 60% unnecessary handoffs while the conv-h = 5 dB has only 30%. Three cases of DHO are better than the conv-h = 5 dB in terms of both the number of handoffs per call and ping-pong handoff parameters. The ping-pong handoffs of DHOs are lower than the conv-h = 5 dB when the mobile speed is between 1 m/s and 2 m/s and higher than that of conv-h = 5 dB when the mobile speed is in the range 0.25 m/s to 0.75 m/s. However, the number of handoffs per call of DHOs is slightly higher than that of the conv-h = 5 dB. This is due to the average duration of calls in DHOs is longer than that of the conv-h = 5 dB.

Fig. 4(e) shows the outage probability of handoff algorithms. The outage probability of the conv-h = 0 dB is very small – less than 0.01. Three cases of DHO have nearly the same values with the peak being slightly higher than 0.05 at the mobile speed of 1.75 m/s. The conv-h = 5 dB is the worst one, its outage probability is much higher than that of DHOs, and its peak value is nearly 0.15 for mobile speed between 1.5 m/s and 1.75 m/s.

5 Conclusion

Radio over Fiber indoor network at 60 GHz is a promising architecture for providing broadband multimedia applications in indoor environments. However, handoff is a critical issue in this network. Conventional handoff algorithms with fixed hysteresis or threshold seem to be difficult to deploy. In this paper, the direction assisted handoff algorithm is introduced with the proposed RoF network. By utilizing the moving direction of the mobile user, there are a limited number of antennas monitored in handoff. In addition, the handoff decision is made by the MS so that it can improve the performance of handoff. The simulation result shows that the proposed algorithm reduces the number of handoffs and increases the number of successful handoffs as well over a wide velocity range of a mobile user. The effect of the proposed handoff algorithm on the handoff delay and the dropped call rate is to be evaluated next.

Acknowledgement

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Van Quang Bien received a B.Sc. degree and an M.S. degree in Electronics and Telecommunications from Hanoi University of Technology, Vietnam, in 2001, and 2004 respectively. Currently, he is working toward his Ph.D. degree in Wireless and Mobile Communications (WMC) group, Delft University of Technology. His research interests include billing, mobility and short-range networks at millimeter wave band.

R. Venkatesha Prasad received a B.E and an M.Tech. degree from University of Mysore, India and Ph.D. in 2003 from Indian Institute of Science, Bangalore, India. During 1994 and 1996 he was working as a consultant and project associate at ERNET lab of ECE Department in Indian Institute of Science. While pursuing Ph.D., from 1999 to 2003, he was working as a consultant for CEDT, Indian Institute of Science, as part of Nortel Networks sponsored project. From 2003 to 2005 he was heading a team of engineers at Esqube Communication Solutions Pvt. Ltd., Bangalore, India. From 2005 until date he is with WMC, TU Delft. He is part of the TPC of many IEEE/ACM conferences and a regular reviewer for many IEEE transactions and other journals. He has one patent and another four under process. He is also a member of IEEE1900, IEEE TCCC, TCCN and AHSNTC. Currently he is also a consultant for Esqube working on innovative voice enabling applications.

Prof. Dr. Ir. Ignas Niemegeers received bachelor degree in Electrical Engineering from the University of Gent, Belgium, in 1970. In 1972 he received an M.Sc.E. degree in Computer Engineering and in 1978 a Ph.D. degree from Purdue University in West Lafayette, Indiana, USA. From 1978 to 1981 he was a designer of packet switching networks at Bell Telephone, Antwerp, Belgium. From 1981 to 2002 he was a professor at the Computer Science and the Electrical Engineering Faculties of the University of Twente, Netherlands. From 1995 to 2001 he was Scientific Director of the Centre for Telematics and Information Technology (CTIT) of the University of Twente, a multidisciplinary research institute on ICT and applications. Since May 2002 he holds the chair Wireless and Mobile Networks at Delft University of Technology, where he is heading the Center for Wireless and Personal Communication (CWPC). He is an active member of the Wireless World Research Forum (WWRF) and IFIP TC-6 Working Group on Personal Wireless Communication. He was involved in many European research projects, in particular ACTS TOBASCO, ACTS PRISMA, ACTS HARMONICS, RACE MONET, RACE INSIGNIA and RACE MAGIC. He is one of the originators of the concept of Personal Networks. He is one of the initiators of the FP6 IP project MAGNET and MAGNET Beyond on Personal Networks, where he is an executive committee member.