THE EFFICIENCY ROUTING ALGORITHM FOR MULTIMEDIA TRANSMISSION IN DIGITAL HOME NETWORK SCENARIOS.

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ABSTRACT

The high-rate Wireless Personal Area Networks (WPANs) which IEEE 802.15.3 standard support, foster the Digital Home Network (DHN) scenarios with high rate multimedia data transmission. Actually, there are a few routing protocols for ad-hoc networks which considered the terminal location information and routing metric to reduce the energy consumption and optimize the routing path in mobile system. Based on other routing protocols, this paper presents the reliable location-based routing algorithm which is an adaptation to these networks.

Keywords: routing, ad-hoc networks, location-based.

1. INTRODUCTION

The high-rate WPANs offer a radically different approach to wireless communications in the digital home network systems. Some estimates predict the market of smart house network devices will be larger than the existing wireless LAN and Bluetooth markets combined by the year 2007 [1]. This is due to the capability of these license exempt wide bandwidth wireless systems to yield low cost, low energy, short range, and high capacity wireless communications links [2]. The actual achievable data rate naturally depends on the particular technology and propagation conditions. The use of those house network devices have already been deregulated in the U.S.A, Korea is set to follow shortly with Japan, China and elsewhere not far behind.

Global interest in the technology is trend to foster the wireless digital home networks which support the wireless high-rate data transmission between the multimedia devices such as digital television, audio system, laptop PC, PDA or gaming devices etc. Device groups make WPANs which are small scale networks called piconets, with a reduced number of users (e.g. up to 10 per piconet). Several independent WPANs may have to coexist in the same area without interfering, so a mean of separating them has to be taken into account. MAC protocol is centrally coordinated, with a PicoNet Coordinator (PNC) which synchronizes the devices (DEVs) and allocates the resources [3].

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Actually, there are also several ad hoc routing protocols such as table-driven (or pro-active) algorithms or on-demand (or reactive) algorithms and particular attention is given to location-based routing protocol. Depending on the network scenarios, the inter-working routing algorithm can be centralized which lead the simple and efficient routing algorithm and distributed solution which is suitable if the system needs a flexible and reliable routing. Then in our view of Digital home network scenarios, the suitable routing algorithm possibly take into account many parameter such as number of terminal, distance (between communicating devices) and range (cover by one device), number of hop, geographical position, relaying policy (power saving, resource sharing, minimize emitting power).

This paper mainly considers the reliable location-based routing protocol for digital home network scenarios which combine different types of routing techniques. The contents of paper include some related works which describe in section 2 then section 3 give an overview about the digital home network scenarios which consider when design the routing protocol. After that, the reliable location-based routing algorithm mainly discusses in section 4. Finally, section 5 gives a short conclusion.

2. RELATED WORKS

High data rate are supported for time dependent and large file transfer applications such as video or digital still imaging without sacrificing the requirement of low complexity, low cost and low power consumption. 20 Mb/s is proposed to the lowest rate for these types of data. Beside that, several data rates would be supported for different consumer applications. A personal operating space is a space about a person or object that typically extends up to 10m in all directions and envelops the person whether stationary or in motion.

Several distributed routing algorithms have been proposed for ad-hoc networks; they can be divided in two groups, the table-driven (or pro-active) algorithms and the on-demand (or reactive) ones. Table-driven protocols (i.e. DSDV[4]) have been developed as an application to ad-hoc networking of distributed routing algorithms designed for wired networks. They mainly differ in which information must be retained by each node. The on-demand (i.e. AODV[5]) algorithms have been proposed as a new solution for routing in mobile wireless networks, not derived by pre-existing solution but designed appositely to meet the specific requirements of ad-hoc networking. These protocols are based on a reactive approach, in which information relative to a destination is collected only when it is effectively required. Routes remain valid for a certain amount of time and are discarded after. This choice allows a significant reduction of signaling overhead (there is no need of periodic or event-driven updates), but can lead to a high initial latency in packet delivery.

In the last few years the growing availability of GPS-enabled devices caused an increasing interest in the research on routing protocols capable to exploit the localization information in the path search procedures [6].

3. HIGH-RATE DIGITAL HOME NETWORK SCENARIOS

One of the most promising commercial application areas for high rate WPANs is wireless connectivity of different home electronic systems. The high speed of data transfer in wireless system means to connect together devices such as televisions, DVD players, camcorders, and audio systems... which would remove some of the wiring clutter in the living room. This is particularly important when we consider the bit rate needed for high definition television that is in excess of 30Mbps over a distance of at least a few meters. The figure 1 shows an example of the DHN devices with some simple connection between each group devices which IEEE 802.15.3 call piconet.

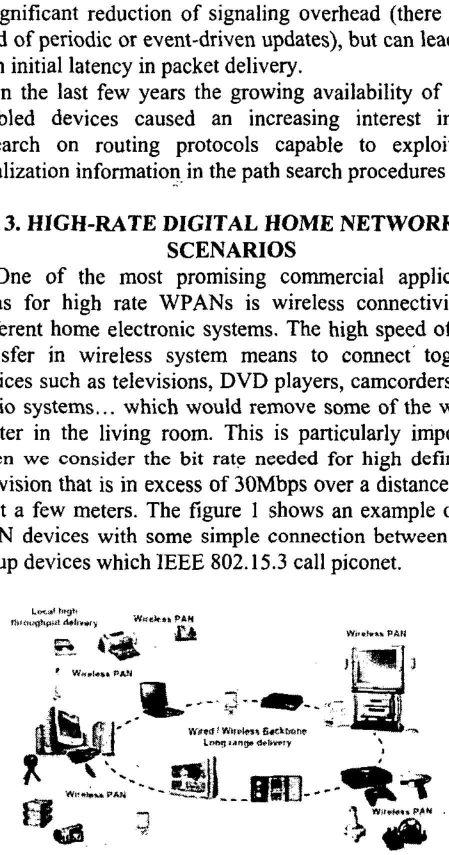

Figure 1 - *Digital Home Network scenario.*

4. RELIABLE LOCATION-BASED ROUTING (RLR) ALGORITHM

RLR is a typical on-demand routing protocol. In order to find a route between source and destination terminal, it relies on a flooding-based *Route Discovery* procedure, which is described below.

Source S starts the procedure by broadcasting a *Route Request* packet to all its neighbors. The packet contains *Source* and *Destination IDs*, and a *sequence number* which uniquely identifies the connection request. Each terminal *I* that receives a *Route Request* packet checks two different conditions: *I* is the intended destination of the packet: if yes, the packet is processed without forwarding. Another packet characterized by the same *Source*, *Destination* and *sequence number* has been already received: if yes the packet is discarded without forwarding. If none of the conditions is satisfied the packet is updated, by including *I*'s ID in the path recorded in the packet, and forwarded to *I*'s neighbors.

The second condition avoids that multiple *Route Request* packets relative to the same connection request are forwarded by the same intermediate terminal, thus reducing the procedure overhead. On the other hand, this means that only one route is allowed by each intermediate terminal, thus reducing the number of potential paths from source to destination (Figure 2).

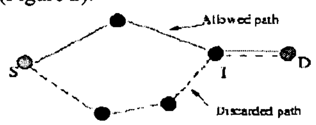

Figure 2 - *Path passing over RLR protocol.*

If the *Route Discovery* procedure succeeds, a *Route Request* packet will eventually reach the destination D. Following the reception of a *Route Request* packet, D starts a *Route Reply* procedure: The forward path from S to D is extracted from the *Route Request* message. Then a backward path from D to S is obtained by reversing the forward path. Also a *Route Reply* packet containing the forward path is sent over the backward path. Following the reception of the *Route Reply* packet S can start sending data packets to D.

Both *Route Discovery* and *Route Reply* procedures may fail for different reasons: Lack of network connectivity between S and D or communication errors. In order to manage such situations a timeout is set by S when a *Route Discovery* procedure is activated. If the timeout expires before a *Route Reply* packet is received a new *Route Discovery* is started, characterized by a different sequence number.

A *Route Recovery* procedure is also defined, as mobility and variable radio conditions may lead to route interruptions during an active connection. A terminal, involved in a path for an active connection which detects a link failure emits a *Route Error* packet, containing the *source terminal ID* and the connection *sequence number*. The packet is then forwarded through the network until it reaches the source S. In order to recover such an error, S starts a new *Route Discovery* procedure searching for an alternative route to the destination D.

RLR exploits location information in order to reduce the amount of routing overhead. The basic location information required consists in *source position, destination position*. Additionally, an estimation of maximum terminal speed is required. Such information is exploited during the *Route Discovery* procedure in following way. Suppose that a terminal S starts a *Route*

Discovery procedure to destination D at time $t = t_l$, and that the last information update regarding D's location $(x_D(t_0),y_D(t_0))$ was received by S in $t = t_0$. Basing on the estimation of the maximum speed v of terminal D, S can evaluate the maximum distance traveled by D since the last location update. Such a distance is given by $d_{MAX} = v(t_l - t_0)$. As a consequence, the current position occupied by D lies in a circular region of radius d_{MAX} centered on $(x_D(t_0),y_D(t_0))$.

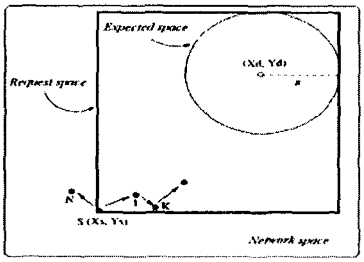

Figure 3 - *Routing scheme*

Inside request space indicates which expected space of the network should be reached by *Route Request* packets. This mechanism reduce the amount of *Route Request* packets flooding through the network, by allowing forwarding of packets generated by the source only in the direction of request space containing the destination.

As most of the location-based routing protocols, RLR assumes the adoption of GPS-enabled terminals. Each terminal has capability to know its own position and speed. However, the knowledge of the position of the destination is also required at the source in order to reduce routing overhead. This means that localization information must be disseminated through the network. Such dissemination is performed by carrying location information in all routing packets. RLR uses time stamps during Route related procedures in order to indicate how recent the carried information is, using the following procedure. Beside that, each terminal in the network maintains a table as presented in table I.

Table 1 - *Position information maintained in each terminal*

Destination	X coordinate	Y coordinate	Last update
$Terminal_1$	X_1	Y_1	t_{X1}
$Terminal_2$	X_2	Y_2	t_{X2}
...	...	...	...
$Terminal_N$	X_N	Y_N	t_{XN}

When broadcasting a *Route Request* packet, source terminal S inserts its own position (X_S, Y_S) and a time stamp indicating when this position information was obtained. Each terminal *I* receiving the packet compares the time stamp in the packet with the *Last update* field in the table entry relative to S: if the information contained in the packet is more recent the table is updated.

Finally, RLR consider the routing metric [7] is based on the introduction of an additive link cost function which is obtained as the sum of several terms taking into account the above aspects, with the general form:

$$C(x,y)=C(power)+C(setup)+C(interference)+C(quality)+C(delay)$$

This formulation should be clear that the cost of a link vary in time and depend also on the parameters (e.g., requested rate) of the originating request from source terminal. The cost of a communication path is the sum of the cost of its links:

$$C(path) = \sum_{(x,y)\in path} C(x,y)$$

In general, there are many possible communication paths between source and destination. The basic routing strategy tries to opt for the path with minimal cost. However, the way such a path is individuated will depend on path search procedure, but this does not affect the definition of link and path costs.

5. CONCLUSION.

The present paper has described the main characteristic of the digital home network scenarios which should be supported by high-rate WPAN, the Reliable Location-based Routing algorithm which based on the characteristic of piconet in IEEE 802.15.3 standard for 2.4GHz. This routing algorithm considers the location of the terminal, routing metric to optimization. The digital devices which are supported high-rate data transmission, this algorithm can be a suitable to make smart digital home spaces. This should be extended the routing metric with various kinds of real digital terminals in the future works.

6. REFERENCES

[1]GBrown, "*Ultrawideband: Spectrum for Free*", Unstrung Insider, W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993

[2]"*Ultra Wire band: Application, Technology and Future perspectives*" Ben Allen, Tony Brown, Katja Schwieger, Ernesto Zimmermann, Wsim Malik, Dàvid Edwards.

[3]IEEE Standard 802.15.3TM "*Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for High Rate Wireless Personal Area Networks (WPANs)*"

[4]DSDV (*Highly Dynamic Destination-Sequenced Distance Vector routing protocol*) - C. E. Perkins, P. Bhagwat

[5]AODV (*Ad hoc On Demand Distance Vector routing protocol*) - C. Perkins, E.Royer and S. Das.

[6]LAR (*Location-Aided Routing in mobile ad hoc networks*) - Young-Bae Ko and Nitin H. Vaidya.

[7]"*U.C.A.N.'s Ultra Wide Band System: MAC and Routing protocols*", Fabrice Legrand, Isabelle Bucaille, Serge Héthuin, Luca De Nardis, Guerino Giancola, Maria-Gabriella Di Benedetto,Ljubica Blazevic, Philippe Rouzet.