MMSP: Designing a Novel Micro Mobility Sensor Protocol for Ubiquitous Communication

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***Abstract*—Designing low power and less delay for mobile nodes is one of the most important issues for the ubiquitous sensor networks (USN). The paper presents a novel Micro Mobility Sensor Protocol (MMSP), as an enhanced form of the AODV (Ad hoc on-demand Distance Vector) protocol, in order to improve the quality of mobile IP (IPv6)-USN nodes. An IP-USN node can include various sensors for application monitoring. In this MMSP technique, IP-USN nodes can easily move to monitor their applications within the range of a PAN coordinator, connected to internet based networks. By using this technique, the user can globally receive sensor data on any internet based equipment such as a PDA, notebook, cell phone, etc. The IETF working group has defined, in RFC 4919 and RFC 4944, standards for IPv6 over Lowpan (IP-USN). We carry out a performance analysis in an NS-2 simulator for, e.g., a small number of IP-USN nodes randomly deployed to monitor a number of targets. Each target (IP-USN) may be redundantly covered by multiple sensors. To conserve routing performance of IP-USN networks, we have organized sensors in sets activated successively. This novel protocol can use monitoring and detection with respect of various applications.**

Keywords—Mobility; IP-USN; AODV; Routing; Global communication.

I. INTRODUCTION

Nowadays, technological development has changed our lives in many ways by providing increased comfort and safety, and has affected almost every field of work and education. One of these fields is that of communication; here it has enriched our lives by enabling us to communicate more easily and, to some extent, more cheaply, with people living in different places on the earth. Information technology is still developing easier, faster, and more accurate technologies to improve the quality of our life. The technologies that enable this connection are called ubiquitous computing technologies. The pervasive nature of IP-based networks allows the use of the existing infrastructure. IP based mobile (cell phone) technologies already exist, and can be connected readily to internet based networks, without the need of intermediate entities like translation base station or proxies. Such a method is specified in open and freely available specifications, which is a situation favorable to, or at least better able to be understood by, a wired audience than would be proprietary solutions. Tools for the diagnostics, management, and commissioning of IP-networks, already exist. Due to the rapid development of new paradigm applications, wireless networks are morphing into IEEE 802.15.4–the standard for Lowpan (Low power wireless personal area networks), which are playing an essential role in the realization of the envisioned ubiquitous world. IEEE 802.15.4 (Lowpan) needs to be connected with other Lowpans as well as with other wired networks in order to maximize the utilization of information and other resources. However, the maximum frame size of IEEE 802.15.4 is 127 octets while UDP and IPv6 have big packet size and no space for applications data. The PANs consist of various IP-USN (IPv6 over ubiquitous sensor networks) nodes. As well, one has to overcome problems such as network overhead, node discovery, and security. When that technology is integrated with IPv6, we have a vast amount of possibilities for implementing applications because IP has been used for a long time and technologies related to it already exist, as IP-connectivity is spreading its influence to all kinds of applications [1] [2].

IP-USN has currently become a hot subject for researcher with the advancement in WSN (wireless sensor networks). This is evolving together with global connectivity between IP-sensor devices and IP-network services. The IETF (Internet Engineering Task Force) working group has been standardizing a new development called 6lowpan (IPv6 over low power wireless personal area networks), which refers to an IPv6 integrated with a Lowpan device [2].

This paper proposes a novel mobility approach and analyses the simulation results of IP-USN networks. We have created an NS-2 simulation-based 6lowpan stack. It, in this stack, presents compression techniques, protocol designs, a mobility approach, data binding techniques, and communication between neighboring nodes in the same environment by diffusing throughout a specific field with inter-PAN networks. The aim of this paper is to develop global communications between IP-USN nodes and service

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providers. The service provider (user) connects directly and checks the current status of the IP-USN based sensor node (for application- data) with the help of an existing wireless internet-based technologies such as cellular, GPS [16], Wifi [17] services used by PDA, notebook, and cell phone [16].

II. RELATED WORKS

So far, many mobility protocols have been proposed based on IPv6 for tunneling mobile nodes, such as HMIPv6 and MIPv6. These have managed to reduce packet losses while the mobile nodes are moving. HAWAII and Cellular IP networks require mobile nodes to manage mobility through path setup messages. The mobility related packets are used in the IP layer at IP traffic. Researchers have followed different approaches to give connectivity to a mobile user when the user is moving. Integrating mobility with an IP-USN node is very useful for applications. IP-USN node has considered IEEE 802.15.4 networks with internet for global monitoring applications. There are a lot of packet losses due to mobility. Few of the following mobility protocols have been proposed for IP-USN networks [3–5].

NEMO (Network Mobility) is a routing based mobility protocol, which requires a mobile router to support the mobility of a WPAN [5]. NEMO provides connectivity to all mobile nodes. Basic Support ensures session continuity for all the nodes. Mobile Node does this by adding routing capability between its point of attachment (Care-of Address) and a subnet that moves with the Mobile Router. It is non-supportive of multi-homing for Mobile Routers [6].

LoWMob & DLoWMob (Intra-PAN Mobility Support Schemes for 6LoWPAN) use static nodes for multi-hop communication between PAN coordinators and mobile nodes in Intra-PAN networks. LoWMob is a network based mobility approach for mobile 6lowpan nodes in which the mobility of the 6lowpan nodes is handled at networks-side. It ensures multiple-hop communication between PAN coordinators and mobile nodes with the help of static node within a 6lowpan. The distributed version of DLoWMob, which employs mobility, supports the distribution of the traffic connection at the PAN coordinators and optimizes a multi-hop path between sources and destinations [7].

PMIPv6 (Proxy Mobile IPv6) is a network based localized mobility scheme. In this system, MNs' movements and setup require routing states. PMIPv6 uses host based mobility protocols, thus it is good for 6LoWPAN mobility management. PMIPv6 is also compatible with any global mobility management protocols such as Host Identity Protocol (HIP), IKEv2 Mobility, and Multi-homing (MOBIKE) [8].

MUNNA (Mobile Ubiquitous Nodes, Negotiation Agent) are techniques where the devices move within a mobile network. It shares the responsibility by revolving the load of smaller devices to bigger network elements such as a PAN coordinator and a mobile router. It hosts a mobile router and a 6lowpan PAN coordinator. Its main function is to maintain a delegation table which is specially designed to support the mobility of sensor nodes or low capacity devices. MUNNA techniques have objectively analyzed the scalability of the system using the throughput and delay measures for benchmarking their performance under the influence of mobility. The IP-USN nodes must be addressable by any corresponding node, independent of its current whereabouts [9].

III. SYSTEM DESIGN

During the earlier development phase, wireless sensor applications focused mainly on environment and industrial monitoring applications, but now different applications are emerging from all fields. The ubiquitous communication has also witnessed a few new applications for wireless sensor networks, but they are a bit different as far as the issues that need to be addressed. Earlier applications focused mainly on the ways to optimize the power consumption in the network, and gave less priority to the reliability of packet transmission. However, in the global scenario the main purpose shifts from power to reliability. So the design of wireless applications should focus more on the reliability of packet transmission, although this does not mean that power consumption should be ignored.

Fig. 1 describes the ubiquitous communication sensor networks for global connectivity between IP-USN node and service provider. In this system IP-USN nodes are able to move easily within the range of PAN coordinator which is integrated with IPv6-based wired networks. Thus, the service provider can easily get to know the current position and its application data on internet provider equipments. This integration will help realize ubiquity by allowing global to access application data across IP-USN system and wired IP-based networks [10] [11].

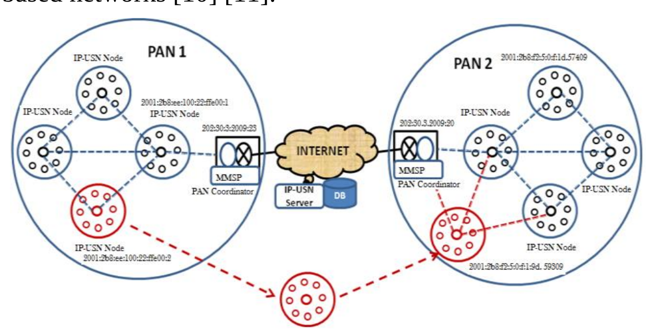

Figure 1. Mobility in ubiquitous communication sensor networks.

In relation to the maximum utilization of resources, they are mainly associated with internet-based networks. These networks are characterized by short range, low bit rate, low power, and low cost. Many devices used are also limited in computational power, memory and energy. The novel MMSP protocol is highly reliant on the availability of other information, such as physical location, global ID, data

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gathering, transmitting to the PAN coordinator, etc. The global ID is desirable in sensor networks. Thus, the sensors can be distinguished from other networks. The sensor node has address space for the global ID, which will cause it to establish communication with IPv6 networks. For the operation of some routing protocols, we do need to distinguish sensor nodes to some extent, but a locally unique ID will suffice [12] [13].

IV. MMSP: MICRO MOBILITY SENSOR PROTOCOL

MMSP works as the back bone of the mobile IP. The idea behind the design is to modify the cellular IP in such a way as to get location information at a particular instant in time and to find the estimated velocity during handoff. To find the location of the IP-USN node at a particular instant in time, directional antennae located on the PAN coordinator are used, directed towards the highest roaming probability inside the PAN or smart networks. In this technique, the PAN coordinator (GW) stores the location information of all IP-USN nodes shown in Table 1. The MMSP knows its radius and maintains a routing table for the each of the IP-USN nodes. The intermediate IP-USN node also maintains a route cache as a PAN coordinator. The PAN coordinators broadcast periodic route query messages to detect available IP-USN nodes in its wireless coverage or PAN. Responding to query messages, all IP-USN nodes in the coverage field send route update messages. After the time elapsed during the exchange of both control packets, the MMSP calculates the distance of the IP-USN from the PAN coordinator or of the PAN coordinator from other nodes. The PAN coordinator keeps the location information of all IP-USN nodes. Table 1 shows the present IP-USN radial component in R1 [14] [15].

TABLE 1. PRESENT IP-USN RADIAL COMPONENT IN R1

IP-USN seq. no.	Location in terms of radius in cm	Location in terms of azimuthal angle in Radian (α &β)	Shortest path
IP-USN (A)	R1	α	MMSP 1
IP-USN (A)	R2	β	MMSP1

The angle of the antenna lobe at which it receives maximum strength from a particular IP-USN, is taken as approximately equal to the azimuthal angle between the two, α. The values of the angles are tabulated as the current positions shown in Table 2. After the completion of consecutive control message exchanges, the MMSP again records the R2 and β for the IP-USN node.

The PAN coordinator maintains a routing table for the IP-USN as shown in Table 2 with its position information. All position entries are taken in circular coordinates. Table 2 is updated with R2, β, using these two position values as well as the time delay between the two entities, the approximate velocity of the IP-USN node is calculated and further updated in Table 3.

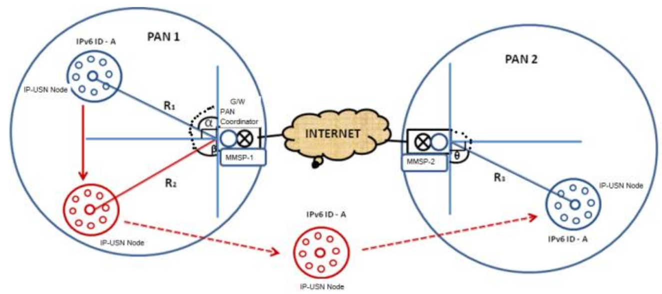

Figure 2. IP-USN mobility in a specific field.

Whenever the MMSP receives a route update packet from the IP-USN, the MMSP updates its route cache. If it receives a route update packet for the first time when a new IP-USN enters its area of coverage, a new entry is made for the IP-USN and the route validation time is set. If the PAN coordinator receives a route update message from an old IP-USN, it refreshes the old route; besides the route update packets, the IP-USN sends a periodic page update packet to the nearest IP-USN.

TABLE 2. MMSP MAINTAINS A ROUTING TABLE IN PAN

IP-USN Seq. no.	Root Valid ation Time	Current Position (R2, β)	Last Position (R1, α)	Velocity [(R2, β) -(R1,α)]/T

The MMSP makes more for complications in structure due to the greater number of directive antennas instead of one omni-directional antenna. Extra computation will be needed on the part of the PAN coordinator.

TABLE 3. MMSP MAINTAINS A ROUTE TABLE FOR THE OTHER PAN

IP-USN seq. no.	Location in terms of radius in cm	Location in terms of azimuthal angle in radian	Shortest path
IP-USN (A)	R3	θ	MMSP2

In Fig. 3 is presented the communication scheme where the PAN coordinator broadcast a query packet to the IP-USN networks (including approximate receiving signal strength for 1st level) at once and then waits for a reply until the timer expires. The timer is set on the IP-USN according to the velocity, signal strength and distance between IP-USN networks and PAN coordinator. Each level has to define the hop distance between the IP-USN node and the PAN coordinator. The PAN coordinator broadcasts a query packet into the mesh topology. The IP-USN node receives a packet within an area that compares to the signal strength, according to an RSS value which the node joins or establishes a connection to the PAN coordinator. Then, the IP-USN node sends a Query_response (IPaddr) packet to the PAN coordinator that the IP-USN nodes are joining with the coordinator. Then, the IP-USN nodes adjust their transmission power to the PAN coordinator for further communication processes.

```
ALGORITHEM
// MMSP Coordinator Functions
while (receivingPacket) {
 //calculate distance
        lastLocation = getLastLocation (packet.nodeId);
        currentLocation = getLocation (packet);
        distance = getDistance (currentLocation,
        lastLocation);
 //calculate interval
        lastTime = getLastTime (packet.nodeId);
        currentTime = getCurrentTime (packet);
        timeInterval = getInterval (lastTime, currentTime);
 //update route information
        velocity = distance/timeInterval;
        updateRouteCache(packet.nodeId,location,currentTi
        me, velocity);
}
// IP-USN Functions
while (periodicTimer) {
        broadcast (updatePacket);
}
// Get Distance
getDistance (currentLocation, lastLocation) {
        distance = lastLocation.R*cos(lastLocation.alpha)
        - currentTime.R * cos (currentTime.alpha);
        return distance;
}
```

Figure 3. Pseudo-code for Micro Mobily Sensor Protocol .

V. PERFORMANCE ANALYSIS

The random waypoint mobility techniques are used during movement of IP-USN nodes. Each node moves randomly within define topology field at a random speed. The speeds are uniformly defined between 1 to some maximum speed. Each node start movement by stationary pause time in value of seconds and after reaching the destination it should stop in pause time seconds as its defined instruction. The mobility will be repeated during simulation process. The mobility process will be set before simulation started there thus we can set the distance of nodes. We have evaluated the proposed MMSP (Micro Mobility Sensor Protocol) by developing a complete simulation in NS 2.33 and through numerical analysis. The terrain area is 500 × 500 m2. A total of 25 number of IP-USN nodes are deployed in a 4 ×4 logical grid. The main reason of dividing the whole area into a grid is to examine the IP-USN node behavior at each step. We have used the random way point mobility model and the fluid flow mobility model. The minimum speed of an IP-USN node is 1 m/s, and the maximum speed varies between 20 m/s, 25 m/s, 30 m/s, and 35 m/s. The IP-USN node pause time is 30 sec. The MMSP is used as mobility enabled routing protocol. The simulation is run for 500 seconds and there are 20 simulations run. The performance metrics of interest are the end-to-end delay, packet delivery ratio, and handoff. The packet delivery ratio is the ratio of the number of packets successfully received by the PAN coordinator, out of the ones that are transmitted by an IP-USN node; and for the communication between multiple IP-USN node packets, the success rate is the number of packets that are successfully received by a IP-USN node out of the ones that are transmitted by another IP-USN node and hand off overhead. Figures 4 and 5 have described the end-to-end delay and the packet delivery ratio of the packets between an IP-USN node and the PAN coordinator. The speed of the IP-USN node and the number of hops between them varies. After a certain number of hops, the end-to-end delay increases linearly with the increasing number of hops between the IP-USN node and the PAN coordinator. Also, the end-to-end delay increases when the speed of the IP-USN node increases. This is because as the speed of the IP-USN node increases, the association of the IP-USN node and sensor node breaks, triggering the handoff process. Thus when the IP-USN node moves with high speed, most of the time is spent to complete the handoff process by the newer and the older IP-USN node. MMSP broadcasts packets by bringing traffic into the network that not only causes collisions but also introduces the hidden node problem. The packet delivery ratio, when the IP-USN node is far away from the PAN coordinator, i.e., 5 hops, is just about 0.4 for an IP-USN node moving with the speed of 20 m/s. As the number of hops between the PAN coordinator and the IP-USN node decreases, the packet delivery ratio increases. And when, the IP-USN node comes closer to the PAN coordinator, the success ratio approaches 1, and the end-to-end delay approaches 0.01 seconds. Moreover, it can be seen from Fig. 4 that, when the speed of the IP-USN node is 20 m/s, the packet delivery ratio is better than when the speed is 25 m/s. This is because as the speed increases, the number of handoffs increases, which can lead to a significant packet loss. Also, when the speed increases exponentially, there is a possibility that the IP-USN node will be lost in the PAN. This is because, as the new IP-USN node wakes up for the handoff process, the IP-USN node may have already crossed the new IP-USN node. As shown in Fig. 5, when the IP-USN node is 5 hops away from the PAN coordinator, the packet

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delivery ratio at the speed of 30 m/s is almost double than that of speed of 25 m/s.

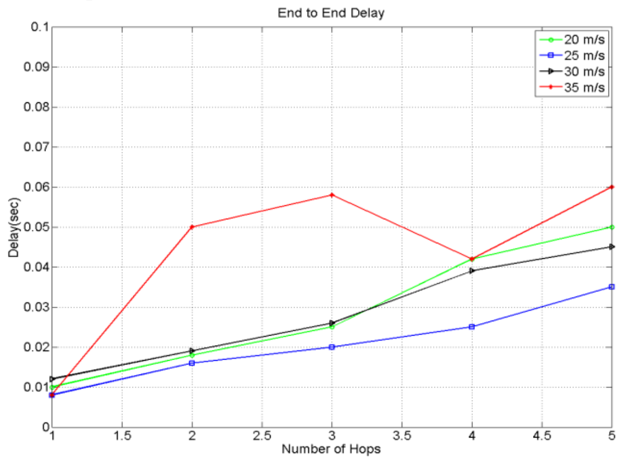

Figure 4 End-to-End delay during IP-USN mobility.

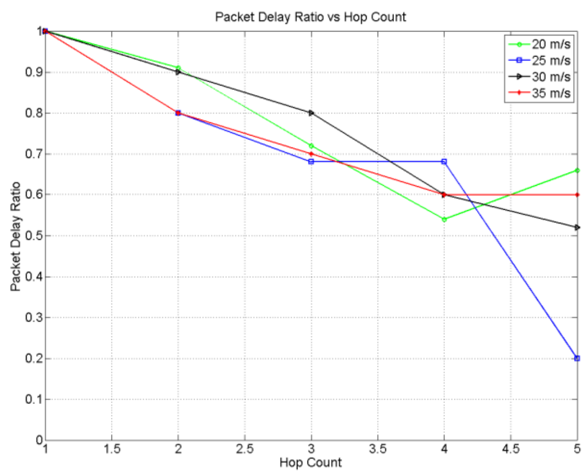

Figure 5. End-to End PDR during IP-USN mobility.

The performance of this novel MMSP in terms of packet delivery ratio and end-to-end delay is good when the IP-USN node is closer to the PAN coordinator. But usually this is not the case, because the IP-USN node can move anywhere within the network. Moreover, as the network size increases, the performance of the novel MMSP algorithm decreases dramatically. Also, as the speed increases, the number of handoffs increases, thus degrading the network lifetime.

VI. CONCLUSION

In this paper, we have proposed a Micro Mobility Sensor Protocol (MMSP) for IP-USN nodes. The node can easily move into the specified field and globally communicate with service providers by PAN coordinator. MMSP is a modified form of the AODV protocol. It comes with a relatively new idea for tackling the increasing performance of various applications such as healthcare monitoring, structural monitoring, location monitoring etc. The application based data packet try to utilize such increasing speed, because currently the increasing speed permits such a kind of system. By using this technique, the service provider globally receives sensor data on internet based equipments such as PDA, notebook, cell phone, etc. This paper is a step towards bringing wireless networking closer to the global communication techniques.

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REFERENCES

[1] N. Kushalnagar, G. Montenegro, and C. Schumacher, "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals", RFC 4919, August 2007.

[2] G. Montenegro, N. Kushalnagar, J. Hui, and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", RFC 4944, September 2007.

[3] H. Soliman, C. Castelluccia, K. El. Malki, and L. Bellier, “RFC-4140: Hierarchical Mobile IPv6 Mobility Management (HMIPv6)”, August 2005.

[4] D. Johnson, C. Perkins, and J. Arkko, “Mobility Support in IPv6”, RFC-3775, June 2004.

[5] E. Nurvitadhi, B. Lee, C. Yu, and M. Kim, “Adaptive semi-soft handoff for Cellular IP networks”, International Journal of Wireless and Mobile Computing archive, Vol. 2, July 2007, pp.109-119.

[6] V. Devarapalli, R. Wakikawa, A. Petrescu, and P. Thubert, “RFC3963 - Network Mobility (NEMO) Basic Support Protocol”, Network Working Group, January 2005.

[7] G. Bag, M. T. Raza, K. H. Kim, and S.W. Yoo, “Inter-PAN Mobility Support for 6LoWPAN”, Sensors 2009, vol. 9, 2009. pp.5844-5877.

[8] S. Gundavelli, K. Leung,V. Devarapalli, K. Chowdhury, and B. Patil, “ RFC-Proxy Mobile IPv6” IETF draft., August 2008.

[9] M. Hasan, A. H. Akbar, H. Mukhtar, K. H. Kim, and D. W. Kim, “A scheme to support mobility for IP based sensor networks”, Proceedings of the 3rd international conference on Scalable information systems, vol. 5, 2008, pp.28-38.

[10] Dhananjay Singh, “IP-Based Wireless Sensor Networks for Global Healthcare Monitoring Applications, (Ph.D. thesis) Dongseo University, Busan, Korea, (*published*) Feb. 2010, pages 217.

[11] E. Kim, D. Kaspar, C. Gomez, and C. Bormann, “Problem Statement and Requirements for 6LoWPAN Routing” draft-ietf-6lowpan-routing-requirements-06 (work in progress) March, 2010.

[12] R. C. Wang, R. S. Chang, and H. C. Chao, "Internetworking Between ZigBee/802.15.4 and IPv6/802.3 Network", Proceedings of ACM SIGCOMM 2007 Workshops, pp. 362-367, Japan, August 27-31, 2007.

[13] T. Winter and P. Thubert, “RPL: IPv6 Routing Protocol for Low power and Lossy Networks”, Internet Draft, June 2010, pages 103, (draft-ietf-roll-rpl-09).

[14] D. Singh and H. J. Lee, “Design and Performance Evaluation of a Proactive Micro Mobility Protocol for Mobile Networks”, chapter in the Book: Handheld Computing for Mobile Commerce: Applications, Concepts and Technologies, IGI Global publisher, USA, Feb. 2010, p.p.328-342.

[15] D. Gao, C. H. Foh, H. Zhang, and L. Liang, “MSRP: A Light Weight Cross-Layer Routing Protocol for IPv6 Wirelss Sensor Networks”, Sensors Journal, 2010, doi : 10.3390/ (*In press*).

[16] http://www.pcmag.com/article2/0,2817,2316534,00.asp (July, 2010).

[17] http://www.webopedia.com/TERM/W/Wi_Fi.html (July, 2010).