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Novel Routing Protocol for Implementing Internet of Nano Things

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Abstract: The Internet of Things is currently a hot research area and has tremendous applications in different fields and helps in performing day-to-day tasks with greater ease & efficiency. This paper presents the use of Nano devices for connecting different things over internet & provides an efficient and detailed description about their working from remote places. For achieving the communication between Nano devices the use of Tera-Hertz band has been proposed by researchers, but there are certain issues in forwarding the messages over Tera-Hertz band. This paper discusses all those issues and finally presents an efficient routing protocol for forwarding the message packets between Nano nodes.

Keywords: Internet of Things, Nano-devices, communication, Tera-Hertz band.

I. INTRODUCTION TO INTERNET OF THINGS

What about to connect the physical world to the internet? That is to say that anything and everything on the planet will become a thing on the internet of things [1]. Then the question arises what exactly are these things that will form the internet of things. We can define a thing on internet of things to be literally anything that can come into the mind of a human being via-goods, objects, machines, appliances, buildings, vehicles, animals, people, plants etc. That is, in the internet of things [2] what we basically do is that we connect everything that an individual possesses to the internet and then control the same via the internet thus making the accessibility and maintenance of things very simple.

The obvious question now arises is that how will we do that?
Let us consider a scenario. Let my chair be a thing on the internet of things. I want to know from any part of the world-is my chair occupied and who is sitting on it i.e. we are converting this chair into a smart chair. To do this, the steps taken are:

- First of all I need to give my chair a unique identity in order to differentiate it from other chairs in the world. Fortunately, IPv6 gives us that luxury. Even if we give IP addresses to all the leaves in the world the address space of ipv6 wont exhaust.
- Give this chair the ability to communicate effectively which is the wireless communication these days.
- Since we want to know if somebody is sitting on it we need to put some kind of sensors on it that can tell us about the environment of the chair. As an example put a sensor measuring presence on the seat and thereby know if it is occupied. Also put an RFId tag reader so that the tagged person can also be identified
- Have a machine control on your chair from anywhere in the world. This can be done by using your smart phone which will have an interface for all the things with whom you are connected to like if u are connected to the things in your kitchen, bedroom, study-room, dining room, they all will have say some icon on your smart-phone an when you click on the study-room, it will list the things you control in the study room an one of them will be this chair we are talking about. Click on the chair and come to know who is sitting on your chair.

The next that comes into the mind is that what will we do with it?
The answer to this query is 7 fold:

- Connect with things in a completely different way: The miracle of IOT is that we can make even the non-living object speak to us and tell us about their location and surroundings. The Nano devices can also be embedded inside human body for measuring any uncertain in working of any human organ. This is not possible without IOT.
- Your smart phone becomes a magic wand. You can walk up to the packet in grocery, look for its price, ingredients etc., find out who was tampering your belongings etc.

  Monitor things: Let us suppose that I have a heart ailment. Without IOT I need to go for regular check-ups for which most of the people are lazy and careless. Plus the hospital may be far away and we may not be in a condition to visit the hospital time and again. With the presence of IOT I can simply be connected to any remote hospital computer which will monitor my condition 24*7 with powerful algorithms and predict months ago that I may be heading towards a problem [3].
- Search for things: IOT will give us the freedom of searching these things on internet:
- Where are my keys?
- Where is my child?

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- Manage Things: we know that 51% of the people now live in cities .We need a way to manage these cities which are quickly becoming megacities. People ask protection of go from getting stuck in a Delhi traffic jam. That is because there are so many cars and so many people. Now with IOT we can have away out where we can understand where vehicles are, where they want to go, so clearly if you know where people are you can control the congestion, make better use of energy and renewables, and look after individual health and security.
- Control Things: with IOT we can control anything and everything, for example government can use it to decide when your washing actually should go to, etc. and thus make the optimum use of electricity. Obviously here the personal benefits or luxury would be compromised but it will be for the benefit of the society as a whole.
- Play with Things: Gaming is one of the big things that happen on internet. It will be even bigger on internet of things.

It has been found out that by 2032 every person will be surrounded by 3000 to 5000 connected everyday things which obviously is transformative. Because of IOT however privacy may become meaningless and too much complexity will creep in since managing 3000 or so things is not an easy task.

A. WHY MOVE TO INTERNET OF NANO THINGS?

As already pointed out, IOT will enable a person to be connected to as many things as he pleases. But then in order to know something about any one of these things we need to install the sensors on the nodes to make them transmit the required information [4]. Now, if I have 3000 devices attached or connected to my smart phone that means anything surrounding me has a sensor of visible range size and that would make the portability an issue. In today's era we want to decrease the size of each and everything and that's what we do in internet of Nano things, we decrease the size of sensors and those sensors become the actual nodes for me.

All of the communication needs to be done with those Nano sensors then and hence we need to make drastic changes to the already existing architecture, routing protocols, security protocols, addressing means etc. [5] Talking about addressing it is an issue in IOT of Nano-things because while in IOT we were using a single sensor on one device we will using multiple Nano sensors on the same device in order to get an exact knowledge about the device's surrounding.

These Nano sensors are called Nano devices. Therefore, we can define a Nano device to be something which senses things and you monitor the thing from anywhere. The application of such devices is vast. For example a father wishes to keep a check on his son's habits like he should not take drugs. For that, he can install a Nano device inside his son's body which will reflect the result via the internet to the parent. Now this type of communication or thing is not possible with normal sized sensors. Hence we shift our attention to the internet of Nano things [6] and see where we need to make a modification to allow for the betterment of things. So, we understand that in IOT using Nano devices the Nano machines are used as the sensor and quite blatantly, we can visualize that the scalability of the nodes need to increase which in turn will increase the precision of the message being transmitted. For example, in IOT we are using a single sensor to detect the location or the presence of water in a bottle but in IOT OF NANO Devices we will use 10 Nano sensors instead of one and hence the precision will be magical.

II. INTER COMMUNICATION AMONG NANO DEVICES

When we make a phone call some 100 km's away, the connection cannot be direct, the call gets transferred from one MSC to the next and so on until it reaches the destination. In the same fashion, when we create a network of Nano things on internet there must be a way in which the Nano machines interact or exchange information with one another.

There are two approaches:

- Electro-magnetic transmission [7]: Since the machines are very small, the antennas of sensors are also very small which implies that the frequency nee will be huge to transmit a message. For such communications, terahertz band is reserved wherein a node sends its message in 10-15 sec. This method is effective when we ought to use air as the medium.
- Molecular communication [8]: Here you place your information into the molecules and the transmitters ,receivers of the machines are such which accept only certain kind of molecules as message and transmit others (when sensing something). This method is suitable when the medium is water.

A. ARCHITECTURE OF INTERNET OF NANO THINGS

There are many components in a network implementing the concept of internet of things, which gather the information pertaining to a particular thing and communicate with each other to provide desired information to the user over internet regarding a particular thing(s). All these components together constitute the architecture underlying the concept of internet of things [9], shown in figure-1, and the constituent components are briefly described as:

- Nano nodes: Tiniest and most basic Nano machines. They have the ability to do the basic calculation, have small memory, and transmission power. All these properties can be attributed to their size. Since the size is less, the energy availability is less an communication capabilities curbed. E.g., Nano sensors in human bodies.

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• Nano router: Collects the information from the Nano nodes (in its vicinity) has more computational ability than that of a Nano node. It is responsible to forward message coming from a Nano node .It also controls the node to some extent with the help of some basic commands such as sleep, switch on, off etc.

• Nano micro-interface: The information coming from a number of Nano routers is aggregated by the interface devices to transmit it to the micro scale and vice versa.

• Gateway: It is the device which gives the authoritative control of the entire system under observation to the internet.

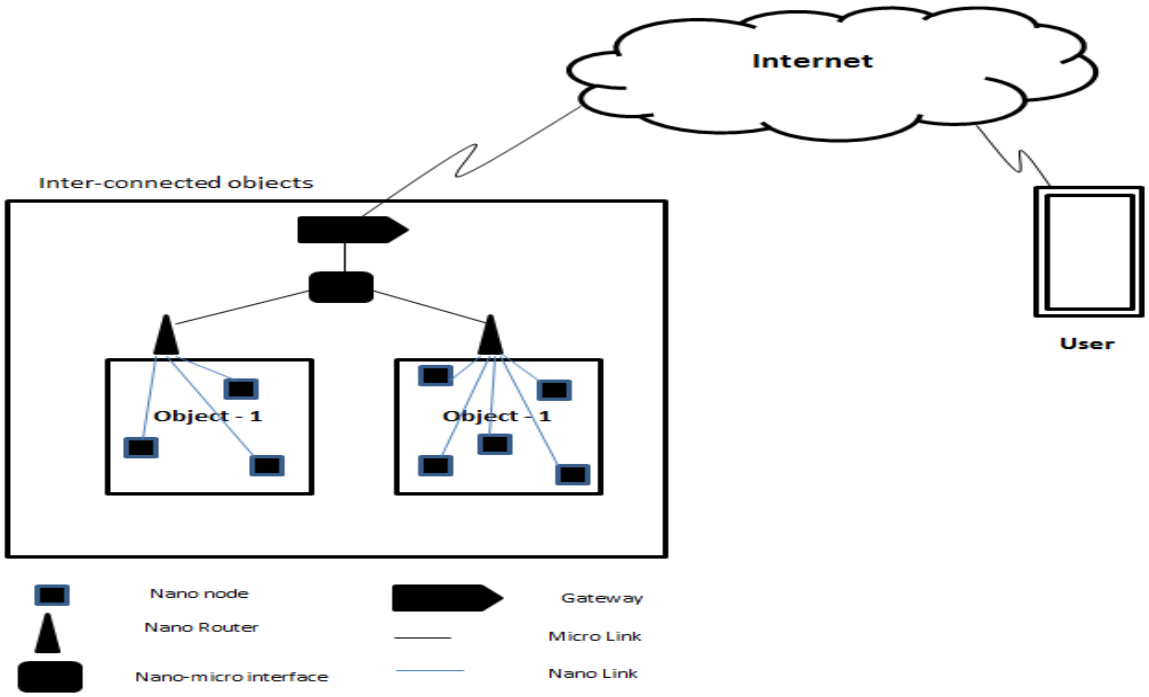

Fig. 1: Architecture of Internet of Things

III.CHALLENGE OR ISSUES IN INTERNET OF NANO THINGS

Currently for a thing to be attached on IOT, we make a combined use of RFID's and WSN. The RFID tag is embodied into any object of interest and WSN is employed for the communication purpose.

Problems with RFID and WSN:

- Although RFID's are small, they do not possess the capability of storing data,processing it or the ability to sense. However they do not need battery for their operation.
- The WSN's provide the sensing, storing, processing functionalities but since we are using sensors on all the objects in IOT while making use of WSN ,it is their (sensors) complexity, size, energy limitations which in turn limit the spectrum of IOT(with WSN as communication technology).

Therefore we move to internet of Nano things. The Nano technology is giving this world one of the most transformative devices which we call the Nano machines/devices. They are really small(of the size of Nanometres). E.g. the Nano cameras can sense the multimedia content and transmit the same.

Blatantly, the precision of that data will be huge and the quality awesome but the only issue is that the quantity of data to be transmitted and that too reliably is tremendous. To accomplish this, apart from hardware challenges there are various other issues which need to be addressed.

- Interaction/communication issue: Since the amount of data is huge, there is a need for data compression. To achieve that, either a new compression algorithm must be devise or there must a change in the underlying architecture of the Nano machine. Also, for Tera-Hertz band communication researchers have proposed the use of Graphene as a material for generating the signals in THz band [10], and a Graphene based antenna has been proposed, which helps in transmission and reception of THz band signal [11].
- Modulation and Encoding schemes: Both of them need to be changed since we use terahertz band in IOMNT data transfer and the existing schemes are sufficient only for WSN communications (where the THz ban is not used). This band gives huge transmission bandwidth (far greater than that of the classical wireless systems). The existing encoding an modulation techniques were actually designed for the channels of limited bandwidth. For this purpose a carbon Nano tube based emitter and decoder has been proposed [12].

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- Addressing: since huge number of devices must be given the addresses, this obviously is a problem.
- Routing: The unique characteristics of the THz band which we use in IOMNT doesn't permit us to make use of the existing protocols for neighbour discovery or routing. Since the THz band allows for the very fast bit rate, the existing routing protocols do not catch such physical layer properties. In addition, the Nano devices need to communicate with each other .For all such things to be successful Resource dynamic protocols must be used. There are 2 solutions:
- Either find a new neighbour discovery protocol which will take into account the high directional nature of Nano antennas and will thereby determine the relative location of 2 neighbours.
- Or develop a new routing protocol which will first use the neighbour discovery strategy and then will calculate the expected wait time to the corresponding machine. This will also tell what modulation scheme will fit best (base on intra node distance and network interference).

IV. PROPOSED ROUTING PROTOCOL FOR IOT

The network underlying the IOT consists of number of micro and Nano nodes which are connected to the Nano routers, the Nano routers are then connected to the Nano micro interface devices (which is responsible for the exchange of information between many Nano routers), which are connected by the gateway (which forms the interface between the internal Nano network of things and the external network i.e. internet). To implement the concept of IOT, we have to use a number of Nano devices which will be responsible for gathering the information from different things from the surroundings and transfer this information to the desired destination. In IOT the network of many Nano devices present at a place are represented by a gateway in internet, which then transfers the information to the desired Nano node in a Nano network. Also the Nano nodes also require the transfer of information between themselves to generate correct, specific and efficient information regarding a particular thing for which they sense.

Thus, the main issue in routing is, how to route the packets between the Nano nodes, because the Nano nodes are extremely small and have highly limited resources. So, the routing protocol to be designed for such a network should have low power consumption at each stage of routing. The routing protocol should also be very much simple, which will consequently decrease the complexity of the hardware. Also, the main challenge for the routing protocol to be designed is that the Nano devices use terahertz band for the transfer of message, providing a very large bandwidth for the message transfer (consequently a very large data rates), thus the routing protocol for such a network should handle such a large data rates, or in other words we can say that the routing protocol should have high throughput. Also, every routing protocol should deliver the packets with least delay and in desired order. Keeping all these considerations into mind, we propose the data-centric routing protocol for implementing the Internet of things, which is energy efficient, has high throughput and less delay and easy to implement.

A. Assumptions

The assumptions for implementing the proposed routing protocol for message transfer in the Nano network, we assume that, there is no direct communication between Nano nodes, all Nano nodes communicate using a Nano router to which they are connected. The position of Nano router is fixed, the Nano nodes which monitor a particular thing are not mobile and each Nano node is given an identifier which is used in routing process. Energy consumed for transmission and reception all the Nano nodes, is same. The communication channel is assumed to have no noise.

B. Routing protocol for implementing Internet of Nano Things (IONT)

The proposed protocol for implementing the IOT is a proactive, but the entire route from the source node to the Nano router is not required to be known. Each node has information about the neighbouring nodes only, thus reduces the memory requirement of Nano nodes. The neighbour table stores: time required to reach the Nano router through that neighbouring node, and the residual energy of the node.

The protocol is generic, and does not depend on a particular architecture. The main feature of this routing protocol is that it is simple, has less routing overhead and less complexity, all of which are the basic requirements for creating the efficient network for implementing the IOT.

C. Packet header

The packet header used for implementing the proposed routing protocol is shown in table – I, where the node energy and the time to reach the Nano router are the main fields for deciding the efficient route in the routing process.

TABLE I PACKET HEADER

Packet Header Fields	Description/Meaning
p_src	Originator of packet
p_dest	Destination node
p_srcack	Acknowledgement originator
p_seq_num	Sequence number of packet
p_start_time	Packet start time at each node
time_to_reach	Time require to reach the Nano router
n_energy	Node energy left

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D. Algorithm

The proposed algorithm has three simple phases: initialization, packet forwarding and route maintenance. A Nano node, besides gathering the information about a particular thing, also calculates a simple function with the help of neighbour table. The neighbour table has: neighbour identifier, time to reach the Nano router through that neighbour, and remaining energy of the neighbour node.

The initialization phase is started by the Nano router, to which the Nano devices are connected, due to which the neighbour tables get initialized. During this process, each node broadcasts only once, thus reducing the routing overhead. After the initialization phase is over then the nodes are ready to route packets to the Nano router. The neighbouring tables are updated using route maintenance mechanism.

Initialization phase: In this phase an initialization packet is broadcasted from the Nano router to all the Nano devices which are connected to that particular Nano router. Once the node connected to the Nano router gets the initialization packet, it first checks whether it is a routing-process packet s a data packet.
If the packet received is an initialization packet, then it updates its neighbour table by initializing the time required to reach the Nano router through that node from which it has received this packet using the information set by the previous node, updates the energy left, and broadcasts it further.

This process continues until all the Nano nodes receive the information about the whole network. Thus, at the end of initialization process all the nodes are able to route the packet efficiently to the desired destination depending on the least value of the time required to reach the Nano router and maximum value of the remaining energy of the node. The time required to reach the Nano router is absolute time rather than hop-count, because knowledge of absolute time reduces the delay and reduces the congestion in network, this is explained in the figure-2.

Suppose there are two paths for transferring the information between nodes A and B (where A represents a Nano router), and first path consists of three intermediate nodes and second path consists of only one intermediate node, and if we chose hop-count as a metric, then second path is ideal for routing between A and B, but if congestion occurs in this path then all the packets may be dropped and this will increase delay in network.

To avoid it, we use the concept of absolute time which is updated in the route maintenance phase, where, if the route maintenance process will detect a congestion in the second path, then it will automatically update the absolute time and the routing process will use first path for routing between A and B, thereby reducing the delay and increasing the delay.

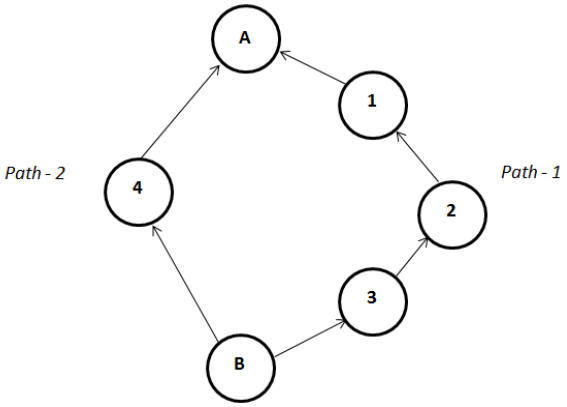

Fig. 2: Intermediate nodes between Nano router (A) and Nano node (B)

Packet forwarding: when a Nano node has a data packet to send, it first checks the priority of data. If the data has highest priority (i.e. if the packet contains data for signalling) then the node with least time-to-reach the destination is chosen from the neighbour table for forwarding.

If the data to be sent is a regular packet containing simple message (which has lower priority), then the source node chooses that node from the neighbour table with maximum available energy for forwarding.

This process repeats at each intermediate node until the packet reaches the desired Nano router, which then routes the packet to its final destination. With this technique, the packet containing the signalling information reaches the destination as quickly as possible, and the packets containing node messages are forwarded in such a way that the node energy of all the intermediate nodes is consumed uniformly.

Thereby increasing the lifetime of network. Also, when the packets are being forwarded by a node, then the remaining energy value is updated, which consequently reduces overhead of route maintenance task. In order to maintain a balance in remaining energy values of different Nano-nodes in a network, an optimal decision in choosing a route for message packets and signalling packets is to be taken.

Route maintenance: whenever a Nano router receives a signalling or a message packet, it should not send an acknowledgment to source, until it receives an acknowledgment from the desired destination. Thus, when a router receives a packet for forwarding, it forwards the acknowledgement received by the destination to its original source.

Using this technique of acknowledging the data received at the destination increases the reliability of network. Another way of route maintenance is to configure the Nano-router to periodically initiate the route initiation process, thereby updating all the neighbour tables.

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V. CONCLUSION AND FUTURE WORK

The paper presented the detailed introduction to Internet of Nano Things, reasons for switching from Internet of Things (IOT) to Internet of Nano Things (IONT), challenges in implementing IONT and finally proposes a routing protocol for implementing the same. Due to the limited energy resources and extremely small size of Nano devices, the proposed routing protocol is designed in such a way that it keeps the complexity and routing overhead to minimum. The proposed routing protocol enhances the applicability of Nano devices by connecting them to one another and helping them to share the gathered information which indeed helps them to produce more accurate and detailed results. In future, the proposed routing protocol will be implemented over a network consisting of Nano devices (which will gather information regarding the things for which they are deployed) for recording the efficiency of proposed routing protocol and further enhance it.

REFERENCES

[1] I.F. Akyildiz, J.M. Jornet, "The Internet of nano-things", IEEE Wireless Communications Magazine 17 (6) (2010) 58–63.
[2] L. Atzori, A. Iera, G. Morabito, "The Internet of things: a survey", Computer Networks 54 (2010) 2787–2805.
[3] P. Ramesh , K. Gurunathan, "Nanomaterials communication inside the living organism", Nano Communication Networks 3 (2012) 252–256 .
[4] I.F. Akyildiz, J.M. Jornet, "Electromagnetic wireless nanosensor networks", Nano Communication Networks Journal 1 (1) (2010) 3–19.
[5] I.F. Akyildiz, J.M. Jornet, M. Pierobon, "Nanonetworks: a new frontier in communications", Communications of the ACM 54 (11) (2011) 84–89.
[6] Falko Dressler, Stefan Fischer, "Connecting in-body nano communication with body area networks: Challenges and opportunities of the Internet of Nano Things", Nano Communication Networks 6 (2015) 29–38.
[7] J.M. Jornet, I.F. Akyildiz, "Channel capacity of electromagnetic nanonetworks in the terahertz band", in: Proc. of IEEE International Conference on Communications, ICC, May 2010.
[8] T. Suda et al., "Exploratory Research on Molecular Communication between Nanomachines," Genetic and Evolutionary Computation Conf. (GECCO), Late Breaking Papers, June 2005.
[9] Josep Miquel Jornet, Ian F. Akyildiz, "The Internet of Multimedia Nano-Things", Nano Communication Networks 3 (2012) 242–251.
[10] A.K. Geim, K.S. Novoselov, "The rise of grapheme", Nature Materials 6 (3) (2007) 183–191.
[11] J. M. Jornet and I. F. Akyildiz, "Graphene-Based Nano- Antennas for Electromagnetic Nanocommunications in the Terahertz Band," Proc. 4th European Conf. Antennas and Propagation, EUCAP, Apr. 2010, pp. 1–5.
[12] M. Rosenau da Costa, O. V. Kibis, and M. E. Portnoi, "Carbon Nanotubes as A Basis for Terahertz Emitters and Detectors", Microelectronics J., vol. 40, no. 4–5, Apr. 2009, pp. 776–78.