ECE/CS 658 PROJECT

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Axis Based Virtual Co-ordinate Assignment Technique for Delivery-Guaranteed Routing in Wireless Sensor Networks

INTRODUCTION:

In this project, I have implemented an algorithm for constructing a Virtual Co-ordinate System in wireless sensor networks. This algorithm is implemented which is devoid of any location information. The Axis based virtual assignment (ABVCAP) technique assigns a unique 5 tuple VC to each of the nodes. It guarantees successful packet delivery in the network.

A wireless sensor network is a network is composed of multiple wireless sensors deployed at random locations. Each sensor collects, process, and store environmental information as well as communicate with others via inter-sensor communication. Now-a-days, the rapid development of wireless communications facilitate the use of wireless sensor networks in our daily lives; a wide range of applications exist for wireless sensor networks, including environmental monitoring, battle- field surveillance, health care, nuclear, intruder detection, etc.

However, routing is an important issue affecting the wireless sensor networks. In the traditional techniques for geographic routing, nodes physical location is used as the node address. The source node determines the destination address by looking it up from the location server [10], or by computing it using a hash function in a data-centric storage scheme.

However, with passing time, more focus is on reducing the cost per sensor node. This includes making the nodes GPS free. Thus, Routing protocols based on virtual coordinates are proposed in wireless sensor networks without GPS assistance. Several types of routing algorithms associated with different routing techniques have been proposed.

DESIGN AND ALGORITHMS:

The design follows a four phase procedure for assignment of the virtual coordinates. Certain assumptions have been made. All the nodes have the same transmission range of R = 1.5. Each node has a unique identifier (ID) used to break ties. Four stages follow with election of anchors followed by implementation of axes (parallel of Latitude and Meridians)

Software Used: Python 2.7 (Networkx modules)

1. **Election of Anchors X, Y, Z, Z' =>**

W is chosen as the sink node randomly.

X is chosen as the node that has the maximum hop distance from W. After which, Y is chosen as the node that has the maximum hop distance from X.

After this, Z is chosen as the node that has the maximum hop distance from W among all nodes whose x and y coordinates each satisfy the relationship, x = y ± 1. In case of parity, the node that has the maximum ID value is selected.

After this, the node that has the maximum hop distance from Z among all nodes whose x and y coordinates each satisfy the relationship x = y ± 1 is selected to be anchor Z' . In case of parity, the node having the maximum ID value is selected.

By the conclusion of this phase, each node has x, y, z, and z' coordinates, where the z' coordinate denotes the hop distance of the node from anchor Z'.

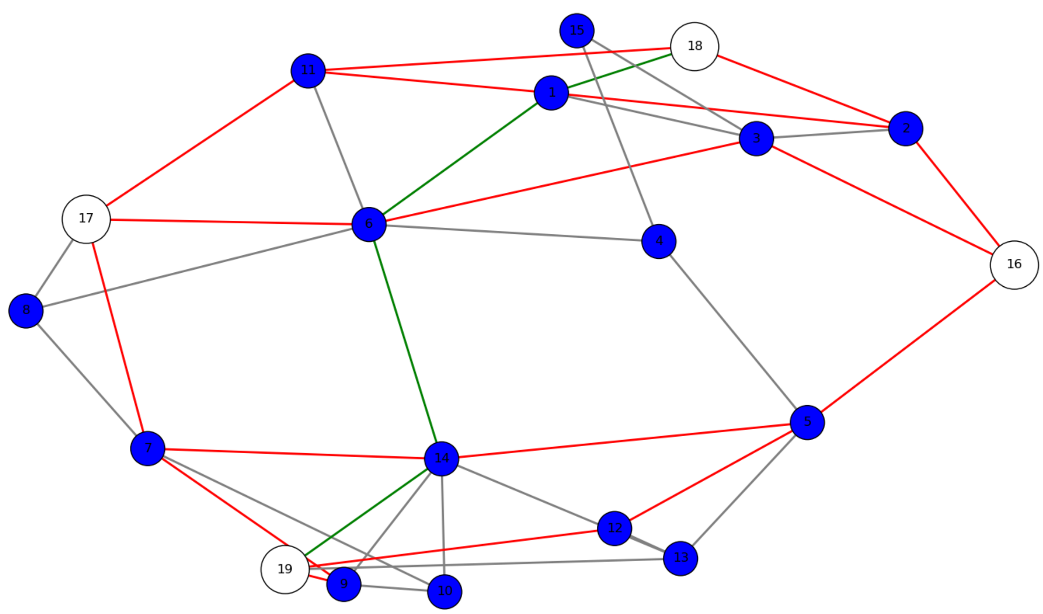


Fig. Implementation of anchors X, Y, Z, Z' in a sample network with 19 nodes

2. **Establishment of Axes – Parallel of Latitude and Meridians =>**

Once the anchors have been elected, axes are established which are used to assign virtual coordinates to the nodes.The parallel of latitude is constructed such that it consists the nodes in one of the shortest paths from anchor Y to anchor X.

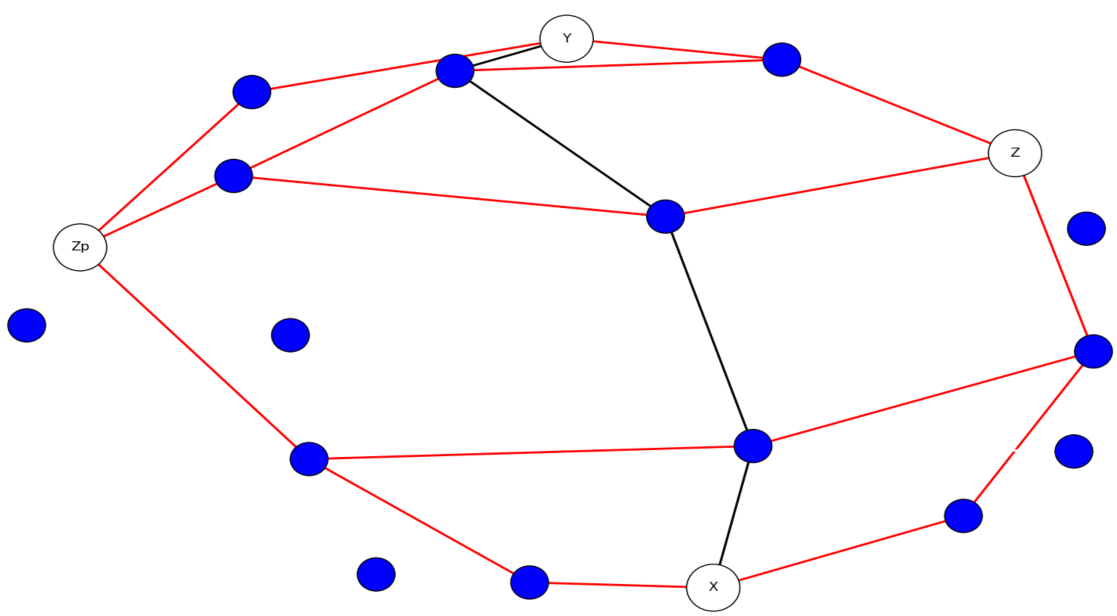
The meridians are formed such as it consists of the node u in the parallel of latitude whose x coordinate is equal to the meridian number, the nodes in one of the shortest paths from node u to anchor Z, and the nodes in one of the shortest paths from node u to anchor Z'.

Parallel of Latitude:
Anchor Y generates a Parallel SET message, which is forwarded by a node to another node whose x coordinate is smaller by 1 until anchor X is reached.
Each node that receives the Parallel SET message is located in the parallel of latitude.

Meridians:
Every node in the parallel of latitude generates a Meridian i+ SET message containing its z coordinate, and a Meridian i- SET message containing its z' coordinate. The Meridian i+ SET (or correspondingly the Meridian i- SET) message is forwarded by a node to another node whose z (or z') coordinate is smaller by 1 until anchor Z (or Z') is reached. If the case where more than one node is eligible to be forwarded, the node having the minimum distance to the node that generates the message is selected.

The distance between two nodes u and v is defined as:
$|u.x - v.x| + |u.y - v.y|$ (u.x, u.y, v.x, and v.y denote the x coordinate of u, the y coordinate of u, the x coordinate of v, and the y coordinate of v, respectively)

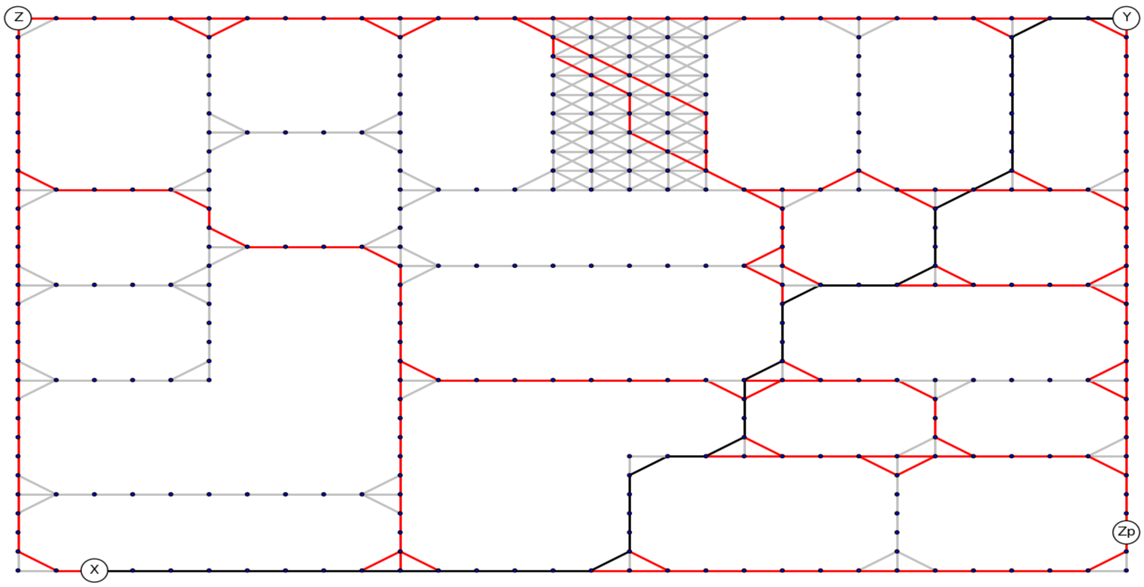
ESTABLISHMENT OF AXES FOR SAMPLE 19 NODE NETWORK



RESULTS OF AXES ESTABLISHMENT FOR DIFFERENT NETWORKS:

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

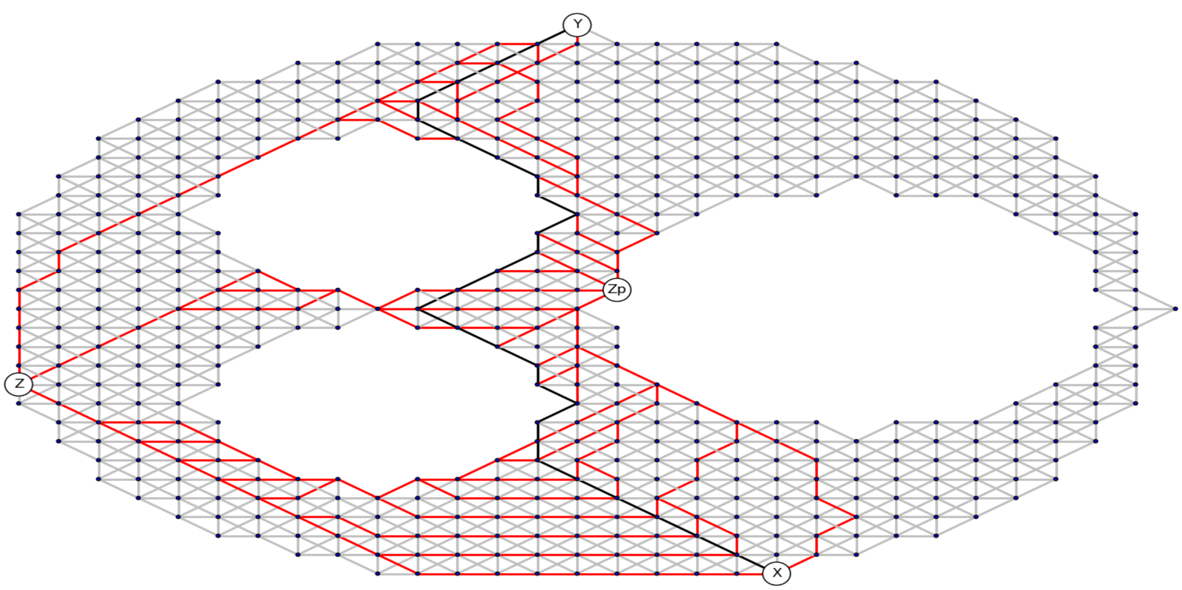
NETWORK IN A BUILDING



Parallel of Latitude -- BLACK   Meridians -- RED

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

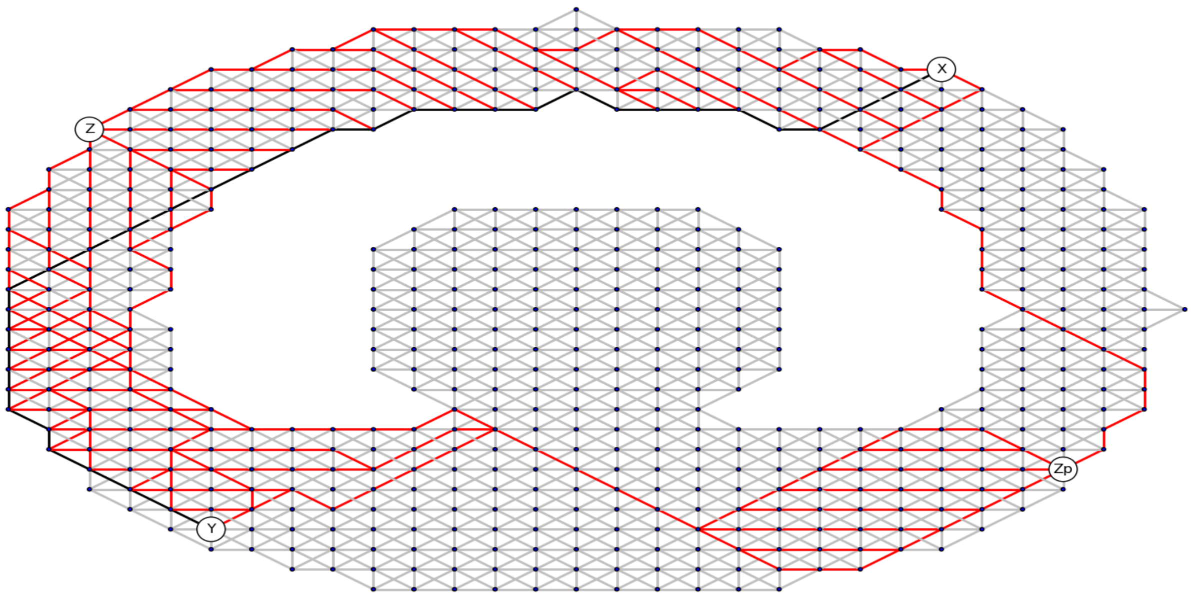
CIRCULAR NETWORK WITH THREE PHYSICAL VOIDS



Parallel of Latitude -- BLACK   Meridians -- RED

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

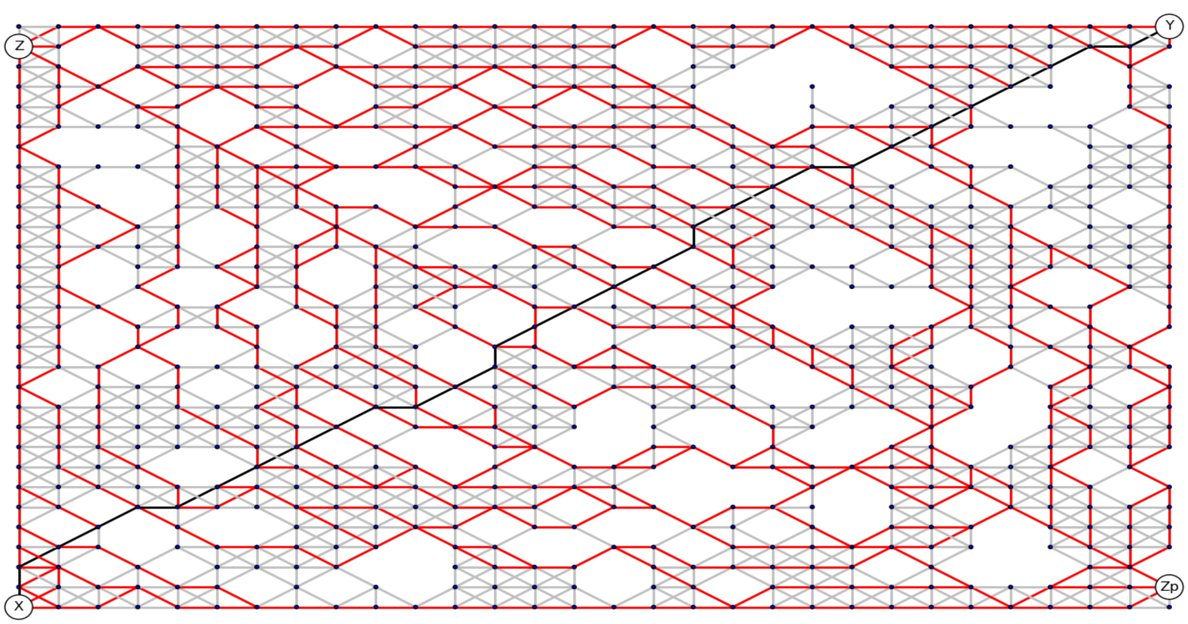
CONCAVE VOID NETWORK



Parallel of Latitude -- BLACK   Meridians -- RED

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

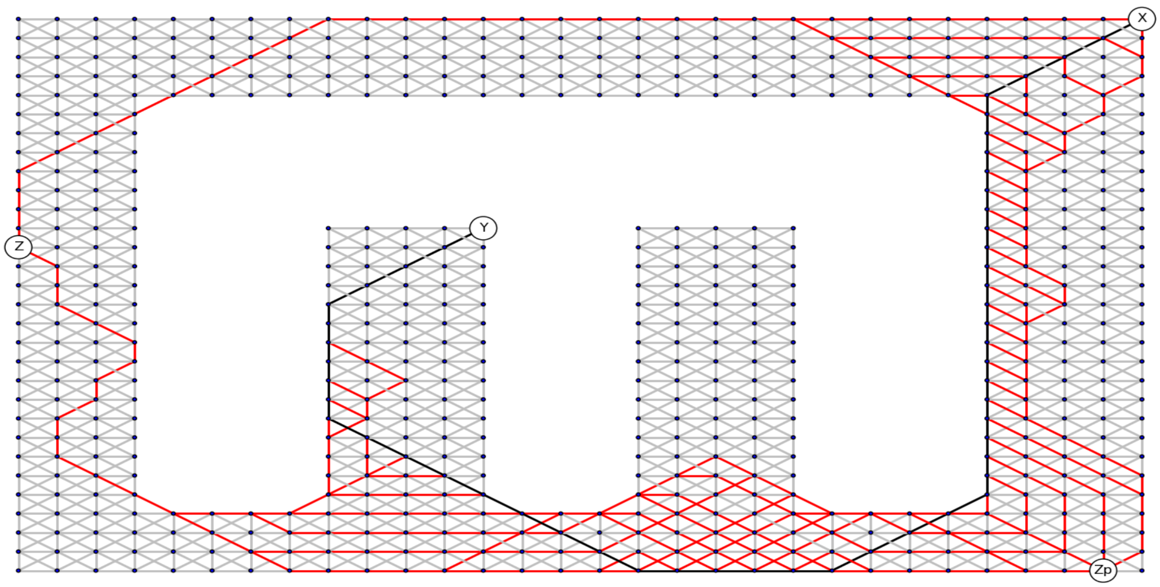
SPARSE GRID



Parallel of Latitude -- BLACK   Meridians -- RED

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

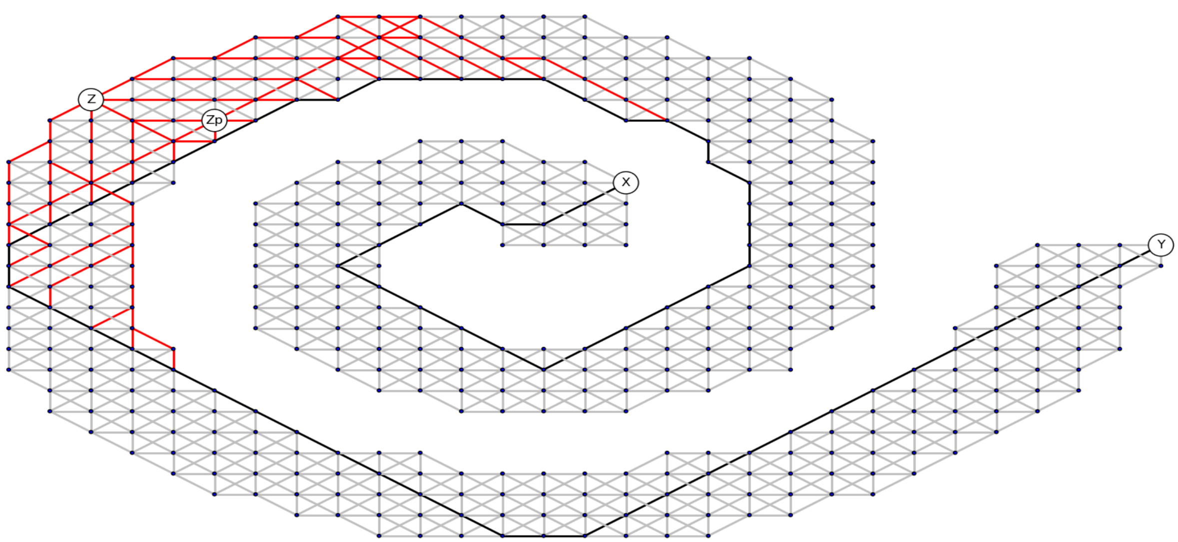
NETWORK WITH VOIDS



Parallel of Latitude -- BLACK Meridians -- RED

ESTABLISHMENT OF AXES FOR NODES PLACED IN A 30X30 GRID

SPIRAL NETWORK



Parallel of Latitude -- BLACK Meridians -- RED

For each of the network topology, depending on the node placement and the voids, the anchor placement varies which later determines the axes positions.

3. Assignment of Longitude, Latitude and Ripple Coordinates:

Once the axes have been established, Virtual coordinates are assigned to all of the nodes based on their placement on/from axis.

PARALLEL OF LATITUDE NODES:
When a node receives the Parallel SET message (for generation of parallel of latitude), the longitude, latitude, and ripple coordinates are assigned to (x,0,0). Here, x is the X-coordinate of the node.

MERIDIAN NODES:
Once a node receives the Meridian i+ SET message, the longitude coordinate is assigned to i (the meridian number), the latitude coordinate to the z coordinate of the node that generates the Meridian i+ SET message minus its own z coordinate, and the ripple coordinate to 0. (for nodes located near to Z) i.e. (i, Zs - Zn, 0)

If a node receives the Meridian i- SET message, the longitude coordinate is assigned to i(the meridian number), the latitude coordinate to its z' coordinate minus the z' coordinate of the node that generates the Meridian i-SET message, and the ripple coordinate to 0. (for nodes located near to Z') i.e. (i, Zs' - Zn', 0)

NON-AXIAL NODES:
Once all the axis nodes have been assigned the first three virtual coordinates, a new phase begins where the longitude, latitude and ripple coordinates are assigned to the rest of the non-axial nodes.

- Every axis node generates a 3COOR_SET message which contains the corresponding longitude and latitude coordinates plus a hop counter initially set to 1 which increases with every hop taken.
- When a non-axis node receives a 3COOR SET message, it locally broadcasts the message, whilst assigning the longitude and latitude coordinates to the longitude and latitude coordinates of the node that generates the message, the ripple coordinate to the hop counter.
- In a condition where more than one message is received from different nodes, the non-axis node broadcasts the message with the lowest hop count and assigns its first three virtual coordinates accordingly.

LONGITUDE, LATITUDE AND RIPPLE COORDINATES FOR SAMPLE 19 NODE NETWORK:

Virtual Coordinate for PL node 1	3,0,0
Virtual Coordinates for MR node 2	4,-1,0
Virtual Coordinates for MR node 3	2, -1, 0 3, -1, 0
Virtual Coordinates for PL node 6	2,0,0
Virtual Coordinates for MR node 11	3,1,0 4,1,0
Virtual Coordinates for PL node 18	4,0,0
Virtual Coordinates for MR node 16	0, -3, 0 1, -2, 0 2, -2, 0 3, -2, 0 4, -2, 0
Virtual Coordinates for NA node 15	2, -1, 1 3, -1, 1
Virtual Coordinates for NA node 4	2,0,1
Virtual Coordinates for MR node 5	0, -2, 0 1, -1, 0
Virtual Coordinates for PL node 14	1,0,0
Virtual Coordinates for MR node 13	0,-1,0
Virtual Coordinates for NA node 12	0,-1,1
Virtual Coordinates for MR node 17	0,3,0 1,2,0 2,1,0 3,2,0 4,2,0
Virtual Coordinates for NA node 8	2,-1,1

Virtual Coordinates for MR node 7	0,2,0 1,1,0
Virtual Coordinates for NA node 10	1,0,1
Virtual Coordinates for MR node 9	0,1,0
Virtual Coordinates for PL node 19	0,0,0

If a node consists of more than one 5 tuple virtual coordinate, it is perceived as multiple virtual nodes located in the same location with each virtual node having exactly one 5- tuple virtual coordinate.

FUTURE WORK:

After this, I will be working on finding the UP/DOWN coordinates of the 5-tuple virtual coordinates based on the longitude, latitude and ripple coordinates. Once all the coordinates are acquired, each node will have at least one 5 tuple coordinate (u.lo, u.la, u.rp, u.up, u.dn).

Based on this coordinates, I will be implementing the routing technique to test the efficiency of the virtual coordinate placement technique and compare it with existing techniques like DVCS for performance evaluation.

CONCLUSION:

ABVCap is one of the most efficient virtual coordinate system as it assigns a unique virtual coordinate to each of the nodes in the WSN. The coordinate assignment is location free which makes the nodes cost efficient without any need of GPS for determining the location of node. ABVCap has no computation needs and need to store the global topological features. Thus, has few requirements in terms of message communication and memory overhead as well.

REFERENCES:

[1] M. J. Tsai, H. Y. Yang, and W. Q. Huang, “Axis based virtual coordinate assignment protocol and delivery guaranteed routing protocol in wireless sensor networks,” in Proc. IEEE Int. Conf. Comput. Commun. (INFOCOM), 2007, pp. 2234–2242.

[2] A. Caruso, S. Chessa, S. De, and A. Urpi, "GPS free coordinate assignment and routing in wireless sensor networks," in IEEE INFOCOM, 2005, pp. 150-160.