The Viability of Implementing Radio Interferometric Positioning System to Obtain Topological Information in MIMO Wireless Mesh Networks

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***Abstract*—Nodes in a wireless mesh network usually gain information about the network topology by using routing protocols to exchange information about the positions of nodes in the network. The use of the radio interferometric positioning system (RIPS) provides a possible alternative, enabling nodes to determine the position of other nodes relative to them. Knowing the relative position of other nodes could prove useful for many different applications. There are possible advantages to using RIPS with MIMO devices when the antennas on the MIMO device are regarded as individual nodes.** [1]

***Index Terms*—Localisation, Mesh Networks, RIPS.**

I. Introduction

Wireless mesh networks consist of static nodes that operate as both hosts and routers [1]. If a node does not have a direct connection to a destination, it uses other nodes in the network to relay information to the desired destination. In order to achieve this the node needs to know along which path the information needs to be sent. This is usually done by using routing protocols to exchange information about the nodes that have direct connections to each other. The problem with this method is that it does not allow nodes to know the locations of other nodes relative to them.

Multiple-input multiple-output (MIMO) radio systems use more than one antenna per node to communicate. The use of MIMO allows for higher bit rates, smaller error rates and improved signal to noise ratios [2].

Radio interferometric positioning system (RIPS) is used in wireless sensor networks to determine the position of nodes [3]. Because of its multiple antennas the use of MIMO systems could provide advantages when combined with RIPS. The aim of this study is to determine if it would be viable to implement RIPS in a wireless mesh environment using MIMO enabled nodes.

Such a technique could be useful in beam forming, location aware services and geographic routing. There could also be improvements in convergence rates when compared to conventional routing protocols.

The rest of the paper is organised as follows: Section II gives a background on RIPS and MIMO, section III describes the proposed research, section IV describes the methodology to be used and finally in section V a conclusion is given.

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II. Background

RIPS was originally developed for use in wireless sensor networks. Unlike conventional ranging techniques which just use the pairwise distance between a single transmitter and receiver, RIPS uses sets of four nodes in its measurements, with two nodes acting as transmitters and two acting as receivers. These measurements do not yield pair wise distances between the nodes involved, but a combination of these distances.Such a measurement is illustrated in Figure 1.

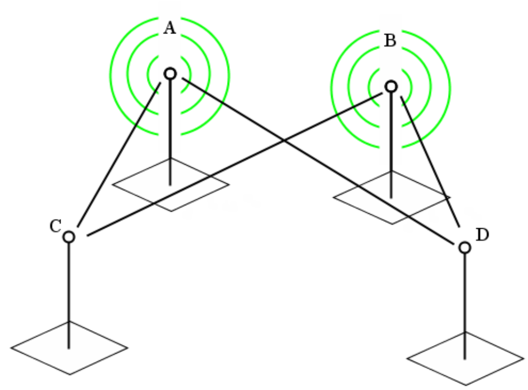

Fig. 1. Illustration of RIPS q-range measurement, with nodes A and B acting as transmitters while C and D act as receivers.

The combination of distances d_{ABCD}, is called the "q-range" and is defined as the following [4]:

$$d_{ABCD}=d_{AC}-d_{AD}-d_{BC}+d_{BD} \quad (1)$$

where d_{AC} is the distance between any two nodes A and C. The transmitter nodes transmit on slightly different frequencies creating low frequency interference of witch measurements are then taken. The relative phase offset between receivers is then used to determine d_{ABCD}. The relationship between d_{ABCD} and the phase offset at the receivers is given by [4]:

$$d_{ABCD} mod \lambda = \phi_{CD} \frac{\lambda}{2\pi} \quad (2)$$

Where λ is the wavelength of the carrier frequency and ϕ_{CD} is the relative phase offset between the two receivers.

In order to determine distances between nodes, multiple q-range measurements must be taken with different combinations of receivers and transmitters. This provides enough linearly independent equations to solve the distance variables. There is a finite number of linearly independent measurements that can be made and this number is dependent on the number of nodes available to be used in the localisation process [5].

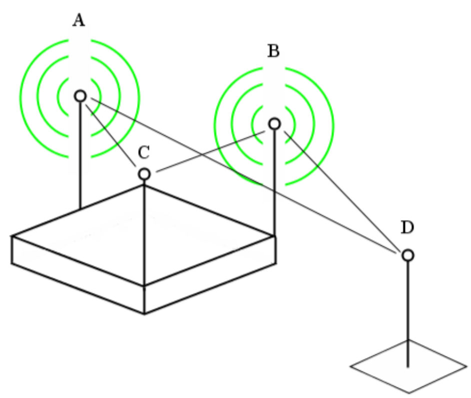

Fig. 2. Illustration of a MIMO device and node to be localised.

III. Proposed Research

The aim of this research is to determine if it would be feasible to use MIMO devices in conjunction with RIPS to determine the relative positions of nodes in a network.Using a MIMO device with antennas capable of functioning independently could provide advantages when combined with RIPS. This is because the antennas have static positions on the device and thus the relative distances between the antennas will be constant and therefore known. With these distances known, fewer RIPS measurements will need to be taken in order to localise nodes. Such a scenario is illustrated in figure 2 with a three antenna device locating a single antenna device.Such a three antenna configuration would be well suited for use with trilateration based methods for solving the individual distances between the nodes. This is because trilateration methods require the position of three nodes to be know.

IV. Methodology

Literature study: A literature study on RIPS and MIMO devices will be done. Relevant physical phenomenon such as near field will also be studied.

Mathematical model: A Mathematical model of the system will be developed. This model will be validated by ensuring that the theories and assumptions that the model is based on are correct and realistic. Relevant physical phenomenon will also be included in this model.

MATLAB Implementation: This model will then be implemented in MATLAB to test whether the mathematical model is logically correct. This will serve as a verification of the model.

Practical Implementation: The results obtained from the previous two steps will be used to design a practical test for the system. Results from practical testing will serve as further verification of the mathematical model.

Interpretation and discussion of results: The results obtained from the mathematical model and it's MATLAB and practical implementations will then make it possible to comment on the following aspects:

- Can RIPS can function on devices with antennas in close proximity to each other?
- What degree of accuracy can be achieved with such a configuration?

V. Conclusion

In this paper we have presented a background of RIPS and from that we have derived a motivation for research into the feasibility of using RIPS with MIMO for localisation in wireless mesh networks. A methodology for the research has also been presented, by following this methodology future work will include the creation of a mathematical model for the localisation system, its implementation in MATLAB as well as practical implementation.

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