Node Mapping and Routing in Wireless Communication

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Abstract: In wireless communication obtaining achievable data rate or throughput is challenging and continuously explored research work. (1) to determine, the topology of the nodes (2) The direction of the data packets from source node to destination node, to avoid packet collision and ensure link.

Apriori, knowing the channel characteristics assists uninterrupted / unfaded / undisturbed data from source to destination (discussed in chapter 3) and helps in Adaptive modulation schemes to coexist (changes in modulation characteristics) to suit the channel conditions.

The transmission with apriori channel knowledge and channel state information feedback
gives better results and achieve high data rate and channel capacity. Frequent path breaks can occur due to random mobility of nodes resulting in increased path loss and transmission errors (frequently occurring problems in mobile network). Multicast node to node communication is supported with localization done through RSSI and triangulation method.

Keywords: Channel fading, Multicast, Adaptive modulation, Node localization, Triangulation, Packet scheduler.

Literature Survey

From Sanjeev Kumar et al (2013) The parameters such as source velocity and outage probability play very important role in the performance analysis and design of the digital communication systems over the multipath fading environment. The outage probability in Rician fading channel is lower than that of the Rayleigh fading channel, (due to the presence of line-of-sight path in the Rician channel). As the speed of the mobile user increases, fading also increases, as most of the signal goes below threshold.

ShaikRiaz and Ramakrishna (2013) focused their work towards improving efficiency in resource usage in multi-protocol label switching networks, since it is essential to utilize label switched path (LSP) efficiently. They provided an efficient distributed bandwidth management solution; it allows bandwidth sharing among backup paths of the same and different LSPs, i.e. both intra sharing and inter sharing with a guarantee of bandwidth protection for any single node/Link failures, besides this proposed efficient algorithm for backup path selection.

In Oloveria (2014), Channel estimation is done by using minimum mean square error in orthogonal frequency division multiplexing signals which are corrupted by fading.

Alex Dytso et al (2013), they have studied the exact capacity region and the sum capacity with partial code book knowledge, and characterized the capacity of the injective semi deterministic integrated circuit (IC) with in a constant gap and specialized it to the Gaussian channel, with linear deterministic approximation of the at high SNR.

AnamIlyas et al (2013) derived the accurate analytical expressions for bit-error and symbol-error rate (BER/SER) of different modulation schemes over Nakagami-m fading channels. These theoretical expressions are extremely important for evaluating the performance of the system without carrying out time consuming simulations. The verification of derived analytical results was carried out for Rayleigh fading channels for m=1. Monte Carlo simulation of the system model was performed to validate the theoretical results for different modulation schemes. The analysis of performance comparison of different modulation schemes, Under Nakagami-*m* fading channels was done using the average bit/symbol error probability. Finally, we did the performance comparison of various modulation schemes under Nakagami-*m* fading channel with other fading channels such as Rician and Rayleigh fading channels and showed that the system exhibits an improved performance in case of Nakagami-*m* fading channels as compared to other fading channels.

Bernard (1997) has defined and examined fading rapidity in channel. Wireless communication experiences packet drops, which might lead to a serious degradation in safety critical connected vehicle applications. The use of wireless communication simulators to emulate the communications performance is reported in with a need to properly replicate the real world vehicular communication environments.

Yahong Rosa Zeng and Cheng Shan (2013), uses statistical simulation models directly to generate multiple uncorrelated fading waveforms for frequency selective channels, multiple input and multiple output channels, and reported to have good agreement among these.

Gummadi et al (2007) presented synchronized frequency hopping among the beacons and receive tag to enable adaptive and continuous network localization.

Bahl et al (2004) presented frequency hopping which is used to explore available capacity over multiple wireless channels.
Srinivasan and Levis (2006) presented that higher RSSI that does not necessarily imply a higher probability to successfully receive the packet.
Liu (2012) enabled off-the-shelf applications and tested the feasibility of key generation with coarse-grained RSSI and with RSSI based localization, with triggering techniques increasing to the ubiquity of RSSI.
Vikas Kumar and Sukhjit Singh (2013), have been evaluating the performance of physical layer with appropriate BER performance through simulation. Operating frequency for any system depending the propagation properties, generally below 6GHz frequency is preferred for mobile communication. Higher modulation schemes not suitable /favorable in all conditions (like, the user near the base station is more beneficial than the user far away from the base station in terms of utilizing the resources effectively). The system resources would have been minimized using higher modulation constellations – it is preferred to the user who is near the base station and it is not suitable for user is far away from the base station. Over all, capacity of the system being increased by/while assigning the modulation based on link condition i.e., Adaptive modulation is the better choice to achieve maximal capacity.
Anish Prasd Shresta and Kyung Sup Kwak (2014), the essential factor in wireless communication system is reliable and faster point to point communication is up to some extent being achieved transmitter diversity and receiver diversity. Here the physical layer security was enhanced with introducing an opportunistic scheduling with transmit antenna selection. Best transmit antenna selection enhance the performance of the channel condition and simultaneous use of maximal ratio combining at the receiver will improve the throughput of the system. They have concluded the secrecy outage probability is almost independent of the number of antennas and eavesdroppers in high SNR region.
Onkar Pathak et al (2014), Positioning is the most attractive technology today. Various technologies are used now days for positioning purpose. GPS is mainly used for outdoor environment.
Non-suitability of GPS in indoor conditions because of its NLOS conditions and signal attenuation has led to several other techniques of indoor positioning. This paper compares few indoor positioning methods and proposes indoor positioning system using tri-lateration method which uses RSSI data from Wi-Fi access points to do localization in indoor environment. Accuracy in positioning can be improved a lot with the combination various technologies like Bluetooth, GSM and RFID's. Indoor system for user and device tracking for security reasons can also be the future scope of the system.
Results show that the positioning accuracy of Wi-Fi indoor positioning using tri-lateration method is around 2-2.5 m. The Accuracy of the system can be further improved if more number of similar access points are deployed in the system. Complex nature of indoor environment is the big hurdle for doing positioning in indoor system. Obstacles like walls, glass, metal objects, and moving objects need to be handled very carefully while positioning.
Together with the wireless power mapping approach, have the potential to provide location awareness to existing wireless devices without the need for aug-mentation of the existing infrastructure. We consider showing that sub-room precision positioning is possible with RSSI readings from a single access point as their major contribution.
Sharma et al (2010), have made extensive study on different modulation schemes for designing effective communication system with fulfilling or to meet requiring modulation metrics or resources i.e. Bandwidth, power, channel noise and bit error rate. Resulting that, QPSK, MSK and GMSK are the better modulation schemes among these GMSK has given or proves better performance for mobile communication.
Smith and Abayapala (2006), This paper has been evaluated the Maximal ratio combining in Rayleigh fading environment with knowledge of channel and without knowledge of channel conditions. This performance especially accounts for the antenna configuration at the receiver, the size and shape of the configuration, and the distributions scattering around the receiver, the results of these paper have showed, practical implementation of maximal ratio combiner in Rayleigh fading channels with typical antenna configuration and modulation schemes. According to this research, there is a probability the effect of non-isotropy antenna shape may lead to better implementations while performing maximal ratio combining at the receiver in Rayleigh fading channels.

Introduction

Channel Characteristics

Channel characteristics differ from one path to the other; channel fading arises from so many factors like, reflection, diffraction, attenuation, and atmospheric ducting, and ionosphere reflection, correlative functions of transmitter, receiver and channel parameters. The channel capacity is an important issue in wireless systems due to available frequency spectrum; current cellular radio systems adopt the concept of frequency reuse to utilize the same frequency repeatedly at different locations. A large frequency reuse distance can enhance the channel quality by reducing low interference but will decrease the system capacity. It optimizes the tradeoff among channel quality, system capacity, and the costs of infrastructure and user terminals. Thus, if multiple signal components of different frequency arrive to the receiver in one direction, then they all experience the same Doppler shift. Certain integer combinations of frequency result in constructive interference and larger signal amplitude, while certain others result in destructive interference and produce small signal amplitude. In addition to variation in signal frequency, if the delay spread (requires the calculation of difference in path length) also varies, then the coherence bandwidth will also differ.

Usually Rayleigh fading is considered as a reference statistical model to measure the propagation effects in wireless devices. Rayleigh fading is the sum of two Uncorrelated Gaussian random variables. If there is no dominant propagation between transmitter and receiver in line of sight environment, Rayleigh fading is applicable, such as the process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel will be Rayleigh distributed. In addition to the scattering if there is strong dominant signal present at the receiver then it is called as Rician fading. In line of sight environment the mean of the random process will no longer be zero, power level of dominant path varies (Rician fading).

Capacity of Wireless Channels (Rate of Communication and Capacity)

Achieving optimal performance of a given channel represents the capacity of the wireless network communication. AWGN channel will be useful to measure the losses in different types of channel environment, it works as a basic channel model for wireless channels. Other fading techniques are comparable with AWGN channel capacity to achieve optimal performance in a network. Using repetition coding error probability decreases exponentially with the block length.

Upto some limit of increasing block length, reliable communication achieved without losing data rate. Any further increment of block length leads to zero data rate since, at one symbol time, the data rate is in excess of one over the block length of bits (i.e., 1/block length)

However, multi dimension is prohibited in repetition coding. Packing maximum number of code words ensures reliable communication.

Node Mapping & Topology Formation

Let: N sensor nodes be available in the network

- Localized node positions are available at the base station.
- With event driven model, the sensor nodes were globally synchronized to determine incoming events along with sensing data reading.
- Sensing data or readings will change with respect to (or) in proportion with distance.
- Difference between a detected sequence and distance sequence notify the ranking difference and describes the faulty node characteristics.
- Numbers of events within sub areas is identified through the map division. Sensor node id's sequences are sorted in order of nodes distances from source node to destination node.
- Prior to the faulty node detection the mapping sequence is done.
- Estimated sequence obtained from the distance sequence which is proportional to sensing results of the number of nodes in the network.
- Distance sequence is obtained through the close proximity of the nodes i.e., if node A is closer than node B, then node A is assigned higher priority.

Configuring The Network

Configuring the network implies furnishing details about the own node or source node and the total number of nodes in the network. All the channel parameters and IP addresses are loaded from text files to the respective arrays. The UDP port is opened for communication in asynchronous mode. Alternately, TCP/IP (with checksum) or secure socket handler (SSH) with encrypted binding are also supported.

Network Layer Design

Given a desired total distance to cover the nodes, the following matrix can be obtained in more than one way. All combinations derived will yield the same required total distance.

Step 1: [Total distance – K] % N = Remainder (say N1) (where % is the modulo and K is a suitable constant)

Step 2: Identify N1 in any Column/Row

Step 3: Sequentially vary N2= N1+ Δ c (2) Where 'c' is a constant and Δ is arbitrary choice.

Step 4: Repeat above steps for all other elements with N_i replaced by N_i+1 in eqn. (6.2).

To illustrate this, the obtained topology of a 4*4 node matrix (for a desired total distance of 66 units) is shown in fig. 1.a to fig. 1.d. with 'K' chosen as 30. Hence N1= [66 – 30] % 4 = 9. The Successive elements are formed with Δ c =1 for that row.

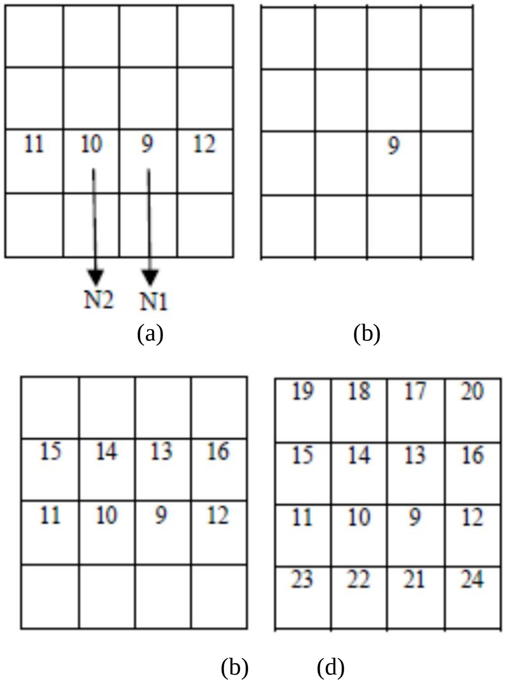
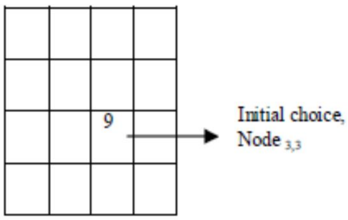


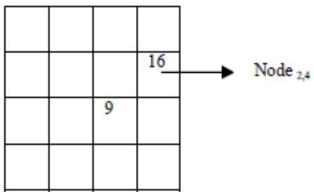
Figure 1 a to d Topology formation

Node Coverage

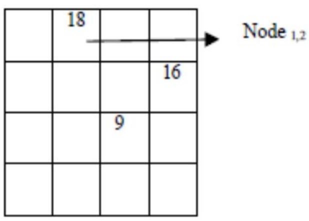
1. Start from Node $_{i,j}$ = Node$_{3,3}$ [Initial choice of i & j is arbitrary].



2. Connect Node $_{i,j}$ with Node $_{p,k}$ such that pk ≠ ij. Example i=j=3 implies p and k cannot have this choice. Hence p=2 and k=4 i.e Node $_{2,\,4}$ is chosen as next choice.



3. Repeat step (2) such that the new node satisfies both the conditions, ≠ ij & ≠ pk. This implies that



In this work, possible m,n values are constrained to
m=1, n=1,2;

m=4, n=1,2;

Thus, m=1 & n=2 is chosen, then Node $_{p,k}$ is connected with Node $_{m,n}$ i.e. Node $_{2,4}$ is connected with Node $_{1,2}$.

4. Repeat (3) till only one node is left over. Possible values are m=4 , n=1 (i.e.) element 23 in Figure 3.d.

	18		
			16
		9	
23			

Node$_{3,3}$ -> Node $_{2,4}$-> Node $_{1,2}$ -> Node $_{4,1}$

Therefore, 9+16+18+23=66

The above nodes formation is not unique. The only Constraint is Node $_{i,j}$ is connected with Node $_{p,k}$ such That $pk \neq ij$. The possible and non-existent paths are shown in Figure 2.

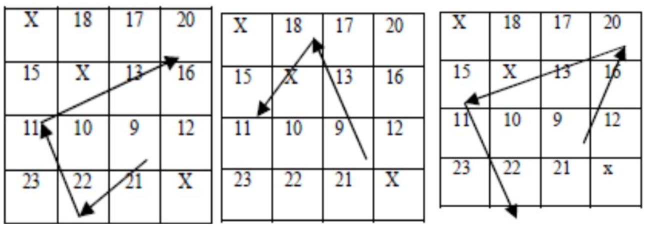


Figure 2 Possible paths

Possible path - (Node$_{3,3}$ -> Node $_{4,2}$-> Node $_{2,1}$ -> Node $_{1,4}$)

a. **Nonexistent path -** (Node$_{3,3}$ -> Node $_{1,2}$-> Node $_{2,1}$)

[Reason : Once Node $_{1,2}$ is chosen the elements of 1st row and 2nd column are prohibited. Thus Node $_{2,1}$ is non-existent since it includes element row=1, column=1 which is already included in Node $_{1,2}$.]

b. **Possible path** - (Node$_{3,3}$ -> Node $_{1,4}$-> Node $_{2,1}$ -> Node $_{4,2}$)

Figure 6.4 Broadcast path formation. Initial Node 3, 3 to broadcast path

Data Transmission

The destination node is entered to receive the message. All possible paths from source to destination node and their corresponding weights depending on the channel parameters of each modulation technique is determined. All possible clusters with their corresponding weights and the cluster that is also a shortest path to the destination is identified and the best cluster is chosen depending on the weight. The input data is modulated and sent over the best cluster path.

Channel Estimation Algorithm

Step 1 **:** Choose Training data set
Step 2 **:** Perform Modulation [i] on Training data set and transmit through channel
Step 3 **:** Measure Channel Characteristics
Step 4 **:** Identify degrees of freedom using chi square value calculation
Step 5 **:** If chi square value for degree of freedom is greater than chi square statistic then accept channel hypothesis.
Step 6 **:** Otherwise Reject Chosen Channel hypothesis. Repeat steps 1 to 5 for other modulations also.

Receiving Message in Asynchronous Mode

If the received node is the destination node, the message is received else the message is forwarded to the next node depending on the best cluster path. After receiving the data, the data is demodulated. If the data has to be forwarded, the demodulated data is again modulated and the modulated data is sent to the next node.

Simulated Output

Case (i): Shortest Path

The algorithm presented is implemented as a verilog core and tested for different combinations of source node and destination node. The simulated results for five nodes for the shortest path message transfer are given in Figure 3.

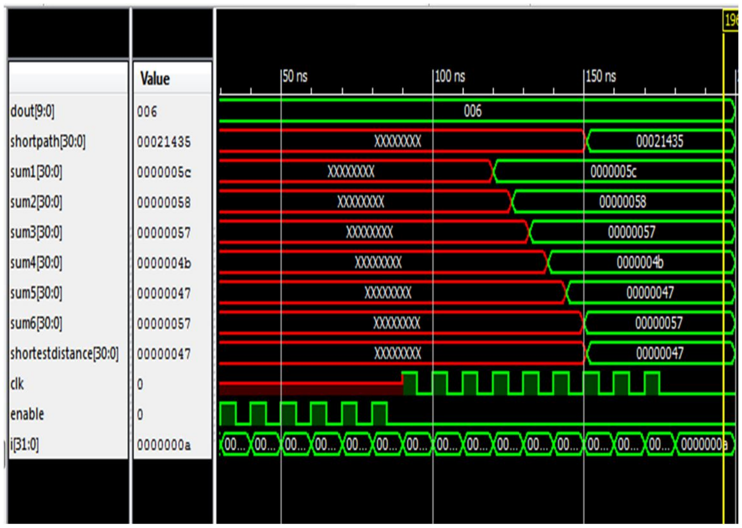


Figure 3. simulated results for five nodes for the shortest path message transfer

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