Analyzing Interaction Between Network Protocols, Topology and Traffic in Wireless Radio Networks

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Abstract— **We study the interplay between network protocols, topology and traffic. A particular interest is to empirically characterize the effect of the interaction between the routing layer and the MAC layer in wireless radio networks. Three well known MAC protocols: 802.11, CSMA, and MACA are considered. Similarly three recently proposed routing protocols: AODV, DSR and LAR scheme 1 are considered. The performance of the protocols is measured with regard to three important parameters: (i) number of packets received (ii) average latency of each packet and (iii) long term fairness.**

We use a simple statistical technique based on *ANOVA (Analysis of Variance)***, to characterize the effect of interaction between protocols and various input parameters on network performance. This technique is of independent interest and can be utilized in other simulation studies. Using our methodology, we conclude that different combinations of routing and MAC protocols yield varying performance under varying network topology and traffic situations. In many cases the results have an important implication; no combination of routing protocol and MAC protocol is the best over all situations. Also, the performance analysis of protocols at a given level in the protocol stack needs to be studied not locally in isolation but as a part of the complete protocol stack.**

Keywords— **Ad-hoc networks, statistical analysis, interactions, ANOVA, MAC layer, routing layer.**

I. INTRODUCTION AND MOTIVATION

Design of protocols for wireless mobile networks is currently an active area of research. Here, we undertake a *systematic* experimental study to analyze the performance of well known MAC/routing protocol combinations for wireless ad-hoc networks. A specific goal is to determine if the performance of a particular MAC protocol is affected by the specific routing protocol used and vice-versa. We consider *static wireless radio networks* in this paper. A companion paper [5] considers the effect of mobility. The results here and in [5] are compared further in Section IV-A and exhibit interesting statistical differences. An empirical analysis for static wireless networks allows us to better understand the spatial distribution of control packets. It also allows us to better understand the effects of network invariants such as cuts and connectivity and path lengths on the network performance.

The work is motivated by research of (i) [3], [4] that studies the interaction between TCP and the lower levels of the OSI stack (ii) [28], [19], [6] that experimentally analyze MAC layer protocols and (iii) recent results by Royer et.al. [8], [9], [22] that note the interplay between routing and MAC protocols. In [22], authors conclude that the MAC protocol selection is a key component in determining the performance of a routing protocol and hence must be considered by any comparative study of routing protocols. Finally, in [25], the authors conclude by saying that a greater understanding is required of cross layer interactions.

A number of recent papers have analyzed the performance of MAC protocols in multi-hop wireless networks [7], [26], [28]. However, to the best of our knowledge, a detailed study aimed towards understanding the effect of interaction between network topology, protocols and traffic using formal statistical tools, has not been undertaken prior to this work. Such methods provide simple yet formal and quantifiable ways to characterize protocol interactions in an ad hoc network. We believe that these ideas are of independent interest and are likely to be useful in other similar settings.

Not surprisingly, our results show that no single MAC protocol or MAC/Routing protocol combination dominated the other protocols across various measures of efficiency. Furthermore, our results indicate that MAC protocols and routing protocols *interact*. We are not aware of any previous studies that undertake such a systematic study. Statistically, *interaction between two factors is said to exist when effect of a factor on the response variable can be modified by another factor in a significant way*. Thus understanding the interaction between static variables such as speed and injection rate can be easily

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captured using statistical methods. On the other hand interaction between protocols is more subtle. We say that protocols interact if the behavior (semantics) of a protocol at a given layer varies significantly depending upon the protocols above or below it. Although it is not easy to capture the initial behavior of the protocols, it is still possible to capture aspects of this interaction by measuring certain system parameters such as number of control packet, changes in routes, etc. The results have direct implications on protocol design. First, they imply that beyond a certain point, performance of a given MAC or a routing protocol should not be considered in isolation. Second, the interaction of protocols with the external parameters such as speed etc. imply that protocols should be designed in such a way so as to be able to engineer them in specific situations. This motivates the design of a new class of parameterized protocols that adapt to changes in the network connectivity and loads. We refer to these class of protocols as **par**ameterized **a**daptive **dy**nami**c** **e**fficient protocols (*PARADYCE*) and as a first step suggest key design requirements for such a class of protocols. These include the ability of the MAC protocols to dynamically change the usage of control packets with change in contention. We will discuss this issue further in the concluding section.

Due to lack of space we refer the reader to [9], [15], [22], [6], [26], [27] for a detailed description and comparison of the routing and MAC layer protocols used in our study.

II. Experimental Setup

Apart from the routing and MAC protocols, our input variables include injection rate and network topology. A detailed list of all the input variables is provided in **Figure 2**.

Our evaluation criteria consists of following basic metrics: (i) Latency: Average end to end delay for each packet as measured in seconds; it includes all possible delays caused by buffering during route discovery, queuing and backoffs, (ii) Total number of packets received[1] (iii) Long term fairness of the protocols, i.e. the proportional allocation of resources given to each active connection. Each of the input parameters and the performance measures considered here have been explored by earlier experimental studies such as [8], [9], [10], [18], [22], [23], [26].

The specific parameter values have been chosen by taking into account the following guidelines: (a) the size of networks and the number of connections were chosen based on the computational limitations of the current simulator and the number of runs we wished to perform, (b) the type of networks chosen were motivated by the earlier studies in [8], [9], [28], [19], [6] and the specific goal of showing interaction betwen the MAC and routing layer, (c) The injection rate chosen is on the higher side when compared to other studies but still very realistic. Moreover, this is done in settings where the results are interpretable; to the extent possible, simple instances are chosen to effectively argue about an issue.

For the sake of simplicity and computational feasibility we decided to use only two connections[2]. This is done so as to make the data analysis and processing tractable and the results more understandable. Additionally for metrics such as fairness, the results in [17] imply that 2-connections might represent the worst case scenario. A companion paper [5] considers how the performance changes as a function of increasing connections.

We now briefly describe the method used to report the average behavior of the protocols. Average number of packets and average latency is simply the average over 10 runs of each protocol over the two connections.[3] For the fairness measure q let $q = (p_1/p_2)$ if $p_2 \leq p_1$ and $q = (p_2/p_1)$ if $p_1 < p_2$. p_1 and p_2 represent the number of packets received over connections 1 and 2 respectively. q measures the deviation from being perfectly fair. The maximum allowed value for q is 6, i.e., if $q > 6$ we set q to 6 to *emphasize smaller values*. Average fairness is $\sum_{i=1}^{10} \hat{q}_i$, where $\hat{q}_i$ is q scaled into $\langle 1, 2 \rangle$ interval for the ith run of the protocol. $\hat{q}$ thus measures the average deviation from being perferctly fair where value close or equal 1 means high level of fairness and value close or equal 2 means high level of unfairness.

III. A Statistical method for Characterizing Interaction

In order to analyze the issue of *interaction* rigorously, we have employed the statistical technique called ANOVA (the Analysis of Variance). ANOVA is commonly used by statisticians to study the sources of variation, importance and interactions among variables.[4] However, to the best of our knowledge, a detailed study aimed towards understanding the effect of interaction between MAC, routing protocols and other input variables, using formal statistical tools, has not been undertaken prior to this work. In a companion paper [5], we used a similar technique to analyze the effect of mobility on the performance of the protocols in ad-hoc networks.

We set up an experiment which evaluates the perfor-

[1] Throughput can be calculated from the number of packets received and hence not been considered separately.

[2] We refer to these as Connection 1 and Connection 2.

[3] This gives a total of 20 runs, 10 from each connection in case of throughput, latency and number of packets received. However, fairness is calculated as a ratio of packets received over the two connections, therefore the number of runs for fairness is only 10.

[4] ANOVA is a linear model. There are alternatives available to ANOVA which can handle much more complex statistical problems. **Bayesian inference Using Gibbs Sampling** is one such method which performs Bayesian analysis of complex statistical models using Markov chain Monte Carlo (MCMC) methods.

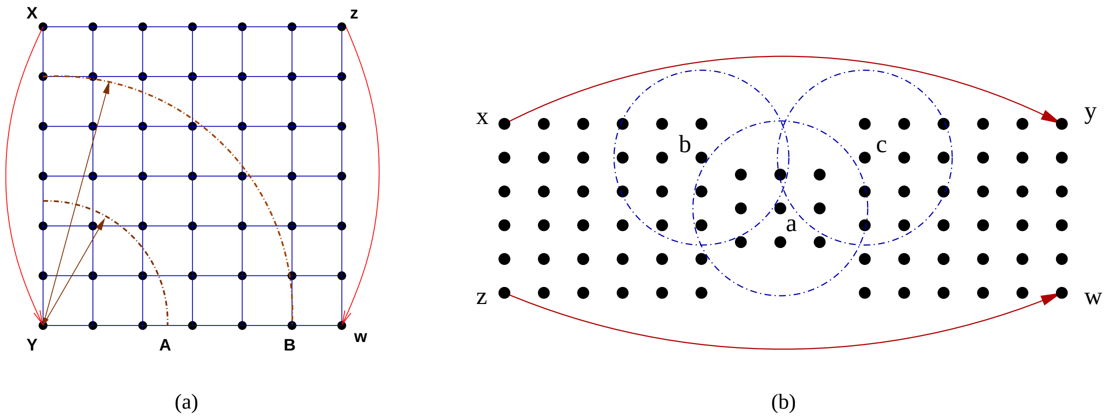

Fig. 1. (a) Medium and high connectivity grid of 7×7 nodes. (A) medium connectivity: the radio range is by the small quarter circle centered at y and (B) high connectivity depicted by the larger quarter circle centered at y. (b) Corridor grid. Two 6×6 grid connected with a 3×3 grid. In each case, we have two connections: one going from x to y and the other from z to w. This pairing is depicted by arrows from source to destinations. For a given experiment, the radio ranges are the same for all nodes.

1. **Network topologies:** medium connectivity grid (Figure 1(a)(A)), high connectivity grid (Figure 1(a)(B)) and 6x6-3x3-6x6 corridor grid (Figure 1(b)). These are denoted by N_i, $1 \leq i \leq 3$, and the set of networks is represented by N. The choice of the networks is based upon earlier work in [6], [26], [28]
2. **Number of connections:** Unless otherwise stated we use two connections.
3. **Routing protocol** : AODV [21], DSR [14], LAR scheme 1 [18]. These are denoted by R_j, $1 \leq j \leq 3$ and the set of routing protocols is denoted by R. The routing protocols were chosen based on the recommendations made by [8], [15] after undertaking a detailed experimental study of recent routing protocols.
4. **MAC protocols:** IEEE 802.11 DCF [1], CSMA and MACA [16]. These are denoted by M_k, $1 \leq k \leq 3$. and the set of MAC protocols is denoted by M. Again the choice of these protocols is based on the study in [22], [26], [7], [28].
5. **Injection rates:** low (0.05 second), medium (0.025 second) and high (0.0125 second) [a]. The injection rates are denoted by I_l, $1 \leq l \leq 3$ and the set of injection rates by I. The initial packet size was 512 bytes, the number of packets was 1,000, and the injection interval was 0.1 second. Each time the injection interval was reduced by a factor of 2, we also reduced the packet size by a factor of 2 but increased the number of packets by a factor of 2. For example, if the injection interval was halved to 0.05 seconds then the new packet size was 256 bytes and the new number of packets was 2,000[b]. This allowed us to keep the injection at input nodes constant in terms of bits per second.
6. The bandwidth for each channel was set to 1Mbit. Other radio propagation model details are as follows: (i) Propagation path-loss model: two ray (ii) Channel bandwidth: 1 Mb (iii) Channel frequency: 2.4 GHz (iv) Topography: Line-of-sight (v) Radio type: Accnoise (vi) Network protocol: IP (vii) Connection type: UDP (viii) Inband control and data; i.e. single frequency for data and control packets.
7. **Simulator used:** GlomoSim [11].
8. The transmission range of transceiver was 250 meters.
9. The simulation time was 100 seconds.
10. Hardware used in all cases was a Linux PC with 512MB of RAM memory, and Pentium III 500MHz microprocessor.
11. The following information was collected to measure the performance: (i) Average end to end delay for each packet as measured in seconds (latency), (ii) Total number of packets received, and (iii) Throughput in bits/second.

[a] Injection rate 0.05 second means that there is one packet injected each 0.05 second, similarly there is one packet injected each 0.025 second and 0.0125 second for medium and high injection rate, respectively. Here we refer to injection rate at source nodes. Injection rate at forwarding nodes is best-effort within limits of protocols at any level.

[b] Thus the packet size is the inverse of injection rate.

Fig. 2. Parameters used in the Experiments.

mance of the following four input variables; the MAC protocol (M), routing protocol (R), network topology (N) and the injection rate (I). Each of these four factors (variables) have three levels (values the variables take). This experiment generates $3^4 = 81$ distinct scenarios by using different combinations of MAC, router, network and injection rate. For each scenario, we generate 10 runs (20 samples; 10 runs for each of the two connections = 20 samples) for the analysis. Our performance matrix for this experiment consists of latency, number of packets received and the fairness. Using ANOVA we study whether these four factors interact with each other, in their effect on the performance measure, in a significant way. In the presence of interaction, the mean differences between the levels of one factor are not constant across levels of the other factor. For more details on interaction and its significance, see [5]. We perform three different analysis, one for each performance measure to observe the interaction among factors.

Approach: We first construct a matrix of 4 dummy variables. For each factor we create a dummy variable. This variable takes a value 1, 2 and 3 depending upon which level of the factor is switched on during the calculation of the performance measure. For example, the dummy variable for MAC protocol, would take a value 1 whenever 802.11 is being used to calculate the performance matrix, value 2 whenever CSMA protocol is being used and value 3 whenever MACA is being used to calculate the performance matrix. Similarly, for the router variable, the dummy takes a value of 1 whenever AODV protocol is being used and value 2 whenever DSR is being used and value 3 whenever LAR scheme 1 is being used to calculate the performance matrix. To calculate interactions between the factors, we use *analysis of variance*. It is a useful technique for explaining the cause of variation in response variable when different factors are used. The statistical details discussed below are routine and are provided for the convenience of the reader. For more details on the techniques used in this analysis, refer to [13], [12]. Given that we have four factors, we use a four factor ANOVA.

Mathematical Model: The appropriate mathematical model for a four factor ANOVA is as follows:

$$y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\alpha\delta)_{il} +$$

$$+ (\beta\gamma)_{jk} + (\beta\delta)_{jl} + (\gamma\delta)_{kl} + (\alpha\beta\gamma)_{ijk} + (\alpha\beta\delta)_{ijl} +$$

$$+ (\alpha\gamma\delta)_{ikl} + (\beta\gamma\delta)_{jkl} + (\alpha\beta\gamma\delta)_{ijkl} + \varepsilon_{ijklm}$$

where y_{ijklm} is the measurement of the performance variable (e.g. latency) for the *i*th network, *j*th router, *k*th MAC and *l*th injection rate. m is the number of samples which is 20 in our experiment. α_i is the effect of network topology, β_j is the effect of the routing protocol, γ_k is the effect of the MAC protocol and δ_l is the effect of the injection rate on the performance measure. The two way interaction terms are; $(\alpha\beta)_{ij}$, that captures the interaction present between the network topology and the routing protocols; $(\alpha\gamma)_{ik}$, which measures the interaction present between the network topology and the MAC protocols; $(\alpha\delta)_{il}$, measures the interaction between the network topology and the injection rates. Similarly, $(\beta\gamma)_{jk}$, measures the interaction between the router and the MAC protocol. $(\beta\delta)_{jl}$, the interaction between the router and injection rates; $(\gamma\delta)_{kl}$, the interaction between the MAC protocols and the injection rates. The three way interaction terms are; $(\alpha\beta\gamma)_{ijk}$, which captures the interaction present between the network, router and MAC protocols; $(\alpha\beta\delta)_{ijl}$, the interaction present between the network, router and injection rates; $(\alpha\gamma\delta)_{ikl}$, the interaction present between the network, MAC and injection rates; $(\beta\gamma\delta)_{jkl}$, the interaction present between the router, MAC and injection rates. Finally the four way interaction is measured by $(\alpha\beta\gamma\delta)_{ijkl}$ which includes all the four factors. ε_{ijklm} is the random error.

Model Selection and Interpretation: Our analysis is based on the method of *backward elimination* where each term is checked for significance and eliminated if found to be insignificant. Further explanation and applicability of the *backward elimination* technique can be found in our corresponding paper [5] that analyzes the effect of mobility. To test four way interaction between the MAC, routing protocol, network and injection rates in effecting the response variable, we perform the four factor ANOVA using the above mathematical model. The sum of squares, degrees of freedom and the F*-test* value for each of the models is shown in the Table I. Interaction column shows which interactions are included in the model.

Performance measure-Latency: Table I shows the ANOVA results. Columns 4-6 show the results for the response variable *latency*. We start with an initial model with all the 4-way interactions and compare it with all 3-way interactions model. Model 14 is being compared with model 13. The F-test, 0.67, shows that the model 13 fits the data as well as model 14 so the four way interaction is not significant. Similarly, we try to find which 3-way interactions are significant and try to find the most important combination by dropping each 3-way term one at a time. Looking at the F-test results of model numbers 9 to 12, we find model 9 to be the most significant and model 12 to be marginally significant. From that we conclude that the router, MAC and injection rates interact most significantly. Also, the network, router and the MAC interact significantly in 3-way interaction. Note that these were the combinations that were dropped off in models 9 and 12.

To find out if there is a smaller model i.e. model with 2-

way interactions that can fit the data as well as the 3-way interaction model, we further look at the 2-way interaction models. We start by looking at a complete 2-way interaction model, i.e. model number 8 and then drop off one term at a time. The F-test values conclude that the most of the 2-way interactions are significant. The only exception is the interaction between router and injection rate. Now we create a model with only the 2-way significant interaction terms and compare it with a model containing only the 3-way significant terms to find that the smallest model that fits the data. If the F-test for these two models turns out to be significant, we conclude that the smallest model includes $[NRM][RMI]$, which means that these 3-way interactions cannot be explained by the 2-way model and hence cannot be dropped off. Our results find that to be true implying that indeed $[NRM][RMI]$ is the smallest possible model.

Performance measure-Number of packets received: Columns 7, 8 and 9 in Table I show the ANOVA results for the response variable "packets received". The interpretation of the results is similar to the response variable "latency". In this case also, the smallest model has only $[NRM][RMI]$ 3-way interaction terms.

Performance measure-Fairness: In this case, the smallest model has only $[RM][NM]$ 2-way interaction terms[5].

IV. Summary of Results

A. Comparison of Statistical Results

In our companion paper [5] we discuss implications of interaction among input variables on mobile networks. In [5], we used three mobility models: (i) Grid mobility model which approximates movement of nodes in a grid (Manhattan) kind of topology, (ii) Exponential correlated random model (ECRM) [24], (iii) Random waypoint model [14]. In Table II we summarize interaction results for the static cases described in this document and the three mobility models. Note that any higher order interaction (e.g. 3-way) automatically implies lower order interaction (i.e. 1-way and 2-way) in the variables. For example, interaction between routing, MAC and injection rate implies that routing protocol and MAC protocol interact; MAC and injection rate interact; and routing and injection rate interact. This holds true even if the F-test shows the lower order interactions to be insignificant.

An important observation about results in Table II is that the interaction between MAC and Routing protocols is significant for each of the response variables. These interactions potentially have important implications. Understanding such interaction might lead to full or partial integration between these two OSI layers. We postulate that this integration will have to be done in totality with the transport layer.

B. Further Results and Qualitative Explanations

In order to explain and quantify the statistical results presented in Section III, we took a closer look at performance variables latency, number of packets received and the number of control packets at the MAC layer level. Table III shows the variation in performance range of *latency* and *packets received* as the injection rate changes from high to low.

1. One typically gets higher latency when using DSR as compared to AODV. LAR scheme 1 is using a similar forwarding mechanism to DSR and does not substantially benefit from GPS information because the networks used for the purpose of this document are static. This is true over all networks and MAC protocols. The working hypothesis is that the packet sizes are generally larger while using DSR since entire route information is embedded in a packet. Note that each of the routing protocols is using some form of route maintenance mechanism in the form of salvaging, unsolicited RREP packets, or RERR packets[6] . In general, routing information at sources is more frequently discarded because of interaction of routing layer with the MAC layer rather than because of its expiration. This is valid even for static networks.

2. In general latency increases substantially with increased injection rate. First note that latency is only measured for packets that are received successfully. Increased injection rate implies higher probability of collision and lower probability of finding free resource. This in turn leads to higher latency.

3. For medium and high connectivity grid and for all injection rates, the system performs the best when using 802.11 and worst when using MACA. This holds for all routing protocols. The results points out the utility of the Carrier Sensing + RTS/CTS/ACK mechanism. However, we have to note that direct (link layer) broken link notification between MAC layer and routing layer was implemented only for 802.11. Performance of ad hoc networking systems is known to suffer if `hello` messages or no notification at all is being used.

V. Concluding Remarks

We undertook a detailed study to quantify the effect of interaction between the individual protocols in the protocol stack and the network and traffic characteristics on the performance of wireless radio networks. The study extends the earlier simulation based experimental work in [8], [9], [10], [18], [22], [23]. Intuitively it is clear that

[5] We have omitted details due to lack of space. Detailed results for the fairness measure can be obtained from the authors.

[6] We have analyzed the impact of routing layer control packets on the overall performance. We have drawn spatial distributions of control packets which show quantities of control packets used in route queries and route maintenance and their relationship to specific nodes.

Response Variable			Latency			Num. of Packets Recd.		
No.	Interaction	Source	SS	DF	F**-test**	SS	DF	F**-test**
1	All 1-way	$[N][R][M][I]$	18733.78	1611	12.61^*	1875199	1611	21.92^*
2	2-way	$[NR][NM][NI][RM][RI]$	16429.57	1591	15.22^*	1535050	1591	31.77^*
3	2-way	$[NR][NM][NI][RM][MI]$	15882.91	1591	0.88	1433837	1591	2.08
4	2-way	$[NR][NM][NI][RI][MI]$	16434.59	1591	15.35^*	1454324	1591	8.09^*
5	2-way	$[NR][NM][RM][RI][MI]$	15998.74	1591	3.91^*	1465026	1591	11.23^*
6	2-way	$[NR][NI][RM][RI][MI]$	17168.48	1591	34.60^*	1682018	1591	74.88^*
7	2-way	$[NM][NI][RM][RI][MI]$	16069.16	1591	5.77^*	1438545	1591	3.46^*
8	All 2-way	$[NR][NM][NI][RM][RI][MI]$	15849.33	1587	3.5^*	1426720	1587	3.71^*
9	3-way	$[NRM][NRI][NMI]$	15346.48	1563	7.5^*	1393866	1563	10.05^*
10	3-way	$[NRM][NRI][RMI]$	14908.73	1563	1.76	1331645	1563	0.93
11	3-way	$[NRM][NMI][RMI]$	14919.62	1563	1.91	1329497	1563	0.61
12	3-way	$[NRI][NMI][RMI]$	14999.95	1563	2.9^*	1347649	1563	3.27^*
13	All 3-way	$[NRM][NRI][NMI][RMI]$	14774	1555	0.67	1325312	1555	0.99
14	All 4-way	$[NRMI]$	14672.34	1539		1311724	1539	

TABLE I

RESULTS OF FOUR-FACTOR ANOVA: THIS TABLE SHOWS RESULTS OF FOUR-FACTOR ANOVA WHERE THE FACTORS ARE NETWORK TOPOLOGY, ROUTING PROTOCOL, MAC PROTOCOL AND THE INJECTION RATE. THE RESPONSE VARIABLE OR THE PERFORMANCE MEASURES ARE THE LATENCY, NUMBER OF PACKETS RECEIVED AND FAIRNESS. $\star$ SHOWS THAT THE F-TEST IS SIGNIFICANT AT 99% CONFIDENCE LEVEL.

Resp. Variable	Static Case	Grid Mobility Model	ECRM	Random Waypoint Model
Latency	[NRM][RMI]	[RSM]	[RSM]	[MI][RS][RM]
Packets Rcvd.	[NRM][RMI]	[RSMI]	All 2-way except [RI][RS]	All 2-way
Fairness	[RM][NM]	[RM][MI]	[RM]	[MI][RM]

TABLE II

COMPARISON OF THE RESULTS BASED ON STATIC NETWORKS PRESENTED IN THIS DOCUMENT AND THE RESULTS BASED ON NETWORKS WITH MOBILITY. FOR MOBILE NETWORKS WE USED AN EXTRA INPUT FACTOR SPEED - S WITH THREE LEVELS: 10 M/S, 20 M/S, 40 M/S. FOR FURTHER DETAILS ON EXPERIMENTAL SETUP SEE [5]

different levels in the protocol stack should affect each other in most cases but this issue is investigated more rigorously here. The statistical method provides a formal approach to characterize the interaction and point out some of the subtleties involved. The statistical method can be used in at least two other contexts: (i) protocol engineering when deploying the ad-hoc networks to choose the best set for given set of conditions and (ii) can provide invariants for simulation validation and calibration.

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Medium Connectivity Grid: Performance range over varying injection rate (High to Low)									
	802.11			CSMA			MACA		
	AODV	DSR	LAR1	AODV	DSR	LAR1	AODV	DSR	LAR1
Latency	0.009-0.02	0.01-0.02	0.01-0.02	0.02-0.01	2-3	0.02-0.04	2-0.02	1-0.05	1-0.04
%Pkts.	100-100	100-100	100-100	90-98	75-64	92-97	62-88	62-83	72-98
High Connectivity Grid: Performance range over injection rate (High to Low)									
	802.11			CSMA			MACA		
	AODV	DSR	LAR1	AODV	DSR	LAR1	AODV	DSR	LAR1
Latency	0.01-0.01	0.01-0.01	0.01-0.02	0.02-0.05	1-4	0.01-1	10-0.01	4-0.06	9-1
%Pkts.	100-100	100-100	100-100	53-58	36-25	38-23	8-80	10-75	23-72
Corridor Grid: Performance range over injection rate (High to Low)									
	802.11			CSMA			MACA		
	AODV	DSR	LAR1	AODV	DSR	LAR1	AODV	DSR	LAR1
Latency	2-0.02	6-0.06	3-2	0.01-0.03	3-3	0.01-0.06	2-0.02	3-0.09	2-0.04
%Pkts.	10-88	18-85	20-62	48-50	38-40	58-56	20-76	18-52	18-68

TABLE III

THIS TABLE SHOWS THE LATENCY AND NUMBER OF PACKETS RECEIVED (%) AS FUNCTION OF INJECTION RATE FOR THE THREE NETWORKS: MEDIUM CONNECTIVITY, HIGH CONNECTIVITY AND CORRIDOR GRID. THE PERFORMANCE IS SHOWN AS A RANGE OVER DECREASING INJECTION RATE.

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