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The IEEE802.11n Capability Analysis Model Based on Mobile Networking Architecture

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Abstract—*Since the IEEE802.11n is implemented with OFDM (Orthogonal Frequency Division Multiplexing) and MIMO (Multiple Input Multiple Output) techniques, the maximum transmission rate can achieve up to 600 Mbps. As compared with the Mobile Wireless Broadband Technology, the maximum transmission rate of 3.5G (HSDPA) and Mobile WiMAX is apparently insufficient (i.e. less than 4Mbps in the upstream) whereas the IEEE802.11n is primarily adopted in the Fixed Networking Environment (FNE). Therefore, provided that the advantage of IEEE802.11n bandwidth can be endorsed under the Mobile Networking Architecture (MNA), the bandwidth bottleneck of 3.5G (HSDPA) and Mobile WiMAX can be addressed and the differentiated application can be fulfilled in the Mobile Wireless Broadband Industry. In this paper, we propose a new model to analyze the capability of IEEE802.11n operated in the Mobile Networking Architecture. By using this model, we can emulate the vehicular ratio within the signal coverage via the Frequency Emulation Module (FEM) and analyze the capability of TCP/IP under the Multiple Access Point (MAP) mode. According to the result of experiment, the TCP/IP capability of IEEE802.11n is optimal in the low-rate Vehicular Internet Environment (VIE). The capability analysis result proved that the proposed Capability Analysis Model (CAM) of IEEE802.11n not only can be applicable under the Mobile Networking Architecture, but also provide a valuable reference for the Mobile Wireless Broadband Industry.*

***Keywords*—Wireless Mobile Networking, MIMO, OFDM**

I. Introduction

The Wireless LAN (WLAN) provides wired hassle-free from traditional LAN and deliver more flexibility and mobility to the networking demand. Since the disruptive launch of Intel Centrino from 2003 and the pervasive deployment of Hotspot, the application of WLAN has been rapidly arisen. The evolution of Wireless LAN can be originated from IEEE802.11 which operates at 2Mbps in the 2.4 GHz spectrum. In 1999, the IEEE also defines IEEE802.11b (11Mbps) and IEEE 802.11a (54Mbps) in the 2.4GHz and 5GHz frequency band. The most recent IEEE802.11g operated at 54Mbps in the 2.4GHz ISM (Industrial, Scientific, and Medical) spectrum has been ratified in 2003.

As IEEE802.11a/b/g is implemented as a single radio channel, it's inefficient for spectral usage in the current Transceiver Design. Thus, IEEE founded a new Task Group (TG) to authorize the project of IEEE802.11n in January 2004, which the transmission rate is escalated to 600Mbps based on OFDM & MIMO technology. The IEEE802.11n can support both 2.4GHz & 5GHz dual spectrum and the channel bandwidth can be increased from 20MHz to 40MHz. The maximum transmission rate can reach 288.9Mbps in 20MHz and it can achieve up to 600Mbps in the 40MHz bandwidth.

Moreover, the MIMO technology implemented by IEEE802.11n has been studied by the researcher. Perdersen *et al.* [6] presented the MIMO can gain optimal channel richness under convoy mode via Vehicle-to-Vehicle (VTV) method while performing the scenario in the Highway. And the channel richness of MIMO can be plunged due to the RF fading when using VTV-Incident mode. The scattering effect will also cause the channel feedback of MIMO surge in a short period of time under VTV-Incident mode. The Capon Spectrum has also been used to differentiate the Angle of Arrival (AOA) phenomenon of electro-magnetic scattering clusters incurred by other surrounded vehicles.

As defined in the IEEE802.11n standard, the application of mobile networking is not restricted [8]. Besides, there're multiple instances for the long-range transmission (e.g. 50KM [14]) in the IEEE802.11n industry. Furthermore, the maximum transmission rate of IEEE802.11n is 600 Mbps [9], which is not only 15 times higher than the IEEE802.11a/g but also thousands of times than the Mobile WiMax and 3.5G (HSDPA) [10-11], while the IEEE802.11n is primarily utilized in the Fixed Networking Environment. Therefore, provided that IEEE802.11n can be adopted in the Mobile Networking Architecture, the performance bottleneck on Mobile WiMAX and 3.5G (HSDPA) can be addressed and the differential application can be fulfilled in the Mobile Wireless Broadband Industry.

In this paper, we propose a new model to analyze whether 802.11n can overcome the current fixed operating mode and then escalate the IEEE802.11n to the Vehicular Internet Environment under the Mobile Network Architecture. By using this model, we can emulate the vehicular ratio within the signal coverage via the Frequency Emulation Module and analyze the capability of TCP/IP under the Multiple Access Point mode. According to the result of experiment, the TCP/IP capability of IEEE802.11n is optimal in the low-rate Vehicular Internet Environment under the Mobile Networking Architecture.

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II. FRAMEWORK OF THE PROPOSED MODEL

The Theorem of the Proposed Model is based on the Transmission Equation presented by Friss *et al.* [7], where the RF (Radio Frequency) Power and Gains of Transmitting and Receiving antennas are jointly-computed with the circumference ratio, wave length and distance vector to obtain the optimal curvature in the unobstructed circumstances as shown in Equation 1.

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \quad (1)$$

We built the model based on Mobile Networking Architecture locally. It is comprised of the Frequency Emulation Module (FEM) and Triggered Endpoint Module (TEM) in the IEEE802.11n Vehicular Internet Environment. The FEM is in charge of RF (Radio Frequency) signal processing in the kernel of the Framework which contains multiple frequency-rate adaptation and configurable scenarios. There are two modules to collaborate with the FEM, which are the 1st and 2nd Trigger Endpoint Module (TEM1/TEM2) dedicated for the layering circulation services between two endpoints. The exterior services including Base Resource Services (BRS) and Subscriber Resource Service (SRS) can be associated to the CAM to perform the correlated interoperability. By using this model, we can emulate the vehicular ratio within the signal coverage via the FEM and analyze the TCP/IP capability of IEEE802.11n under the Mobile Networking Architecture as shown in Figure.1.

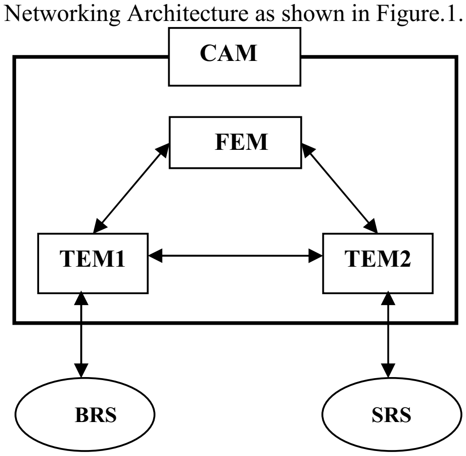

Figure 1 Framework of the Proposed Model

A. Trigger Endpoint Modules (TEM)

The TEM can be divided into four execution modules, which are the Micro Co-Processing Module (MCM), Switching Fabric Modules (SFM), Socket Emulation Module (SEM) and the Statistical Computing Modules (SCM). The Switching Fabric Module is utilized for the circuit-level association and precedence to the FEM. The Socket Emulation Module is used to emulate the process of protocol manipulation and replication. The Statistical Computing Module is used to calculate the outcomes of the SEM in a statistical methodology and then relays the computation result to the MCM. The Micro Co-Processing Module is dedicated for managing and organizing the consequences of SFM, SEM and SCM through the instructive sequential command. The SFM can be associated with the optional Frontend Synthesizing Module (FSM) to provide bias control over the Base Resource Service or Subscriber Resource Service as shown in Figure 2.

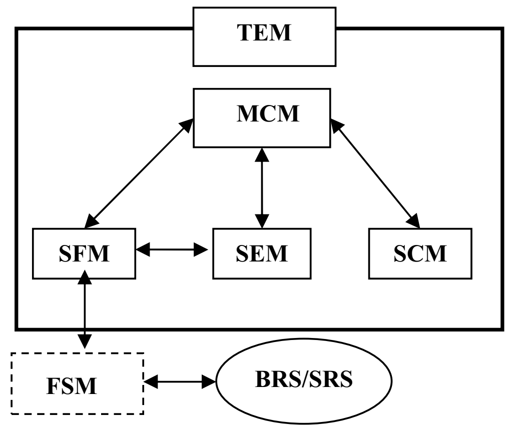

Figure 2 Framework of the Trigger Endpoint Model

B. Frequency Emulation Module (FEM)

The FEM is comprised of three elements, which are the Channel Modeling Module (CMM), Spatial Estimation Module (SEM) and Spatial Steering Module (SSM). The Channel Modeling Module is implemented as the synthesizer with the Radio Frequency and then distributes the rate-adaptive signal processing to the SEM and SSM. The Spatial Estimation Module is implemented to evaluate the probability of the signaling precedence to the Trigger Endpoint Modules and then retrieve the RF from the Channel Modeling Module. The Spatial Steering Module establishes the electromagnetic beam to provide coding sequence in blocks and then propagates the energy to the TEM. The Layering Generation Module (LGM) can be interpolated between the SSM and SEM to distribute the modeling payloads to the Frequency Emulation Module as shown in Figure 3.

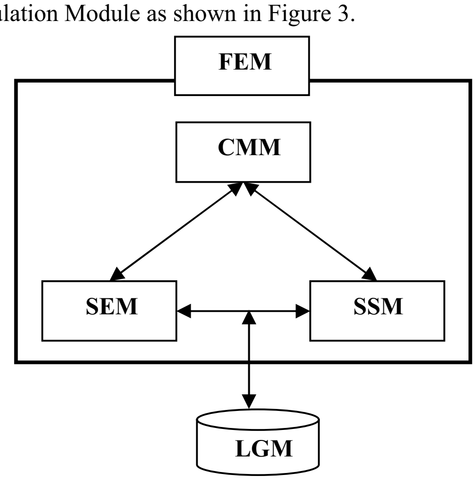

Figure 3 Framework of the Frequency Emulation Module

III. MODEL IMPLEMENATION

For practical implementation, we built an emulation LAB scenario which presents the IEEE802.11n Mobile Nodes (MN) operated under the Multiple Access Point (MAP) mode within the signal coverage of 3.6KM per AP. And then the IEEE802.11n Mobile Station (MS) is moving in the dedicated rate of Vehicular Internet Environment as depicted in the Figure 4. The IEEE802.11n AP was also used for providing physical association to the IEEE802.11n Mobile Station. The Low, Medium and High adaptive-rates in the Frequency Emulation Module have been defined to differentiate the vehicular ratio under the Mobile Networking Architecture.

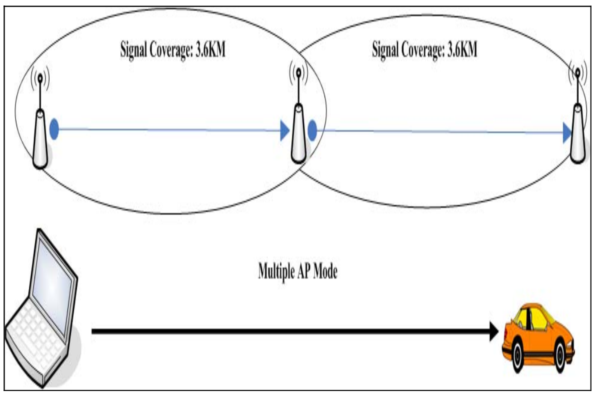

Figure 4 Implementation of the Proposed Model

By using the proposed model, we can obtain the capability analysis result of IEEE802.11n TCP/IP under the Mobile Networking Architecture. The experiment result proved that the IEEE802.11n can achieve optimal capability in the low-rate Vehicular Internet Environment as listed in the Table 1. The synthetic polygon depicts the Low-Rate vehicular scenario can provide maximum capability under the Mobile Networking Architecture as shown in the Figure 5.

Table 1 The capability analysis result of IEEE802.11n TCP/IP under Multiple Access Point architecture

FEM Rate	Throughput (Mbps)	Transaction Rate (s)	Response Time (s)
Low Rate	59.102	0.347	2.886
Medium Rate	21.26	0.033	30.091
High Rate	15.362	0.018	59.124

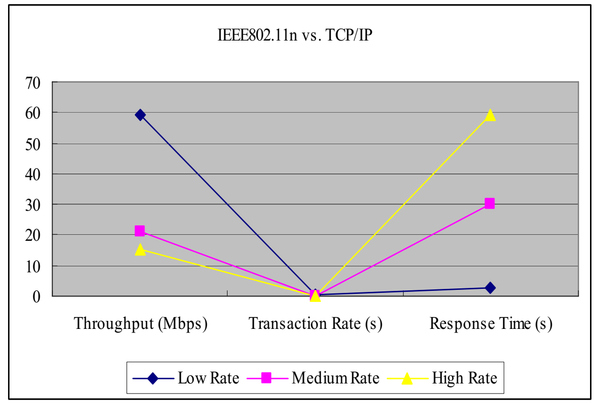

Figure 5 The capability polygon of IEEE802.11n TCP/IP under Mobile Networking Architecture

IV. CONCLUSIONS

At present, the IEEE802.11n has been pervasively implemented in the metropolitan or long-range wireless access method throughout the world and it is the most prevalent wireless implementations for NB, CE and Netbooks. Furthermore, the IEEE802.11n can provide thousands times of transmission rate than the Mobile WiMAX and 3.5G (HSDPA) whereas the IEEE802.11n is primitively adopted in the Fixed Networking Environment. Therefore, provided that IEEE802.11n can be endorsed in the Mobile Networking Architecture, the bandwidth bottlenecks on Mobile WiMAX and 3.5G (HSDPA) can be addressed and the differentiated application can be fulfilled in the Mobile Wireless Broadband Industry.

In this paper, we propose a new Capability Analysis Model of IEEE802.11n under the Mobile Networking Architecture. By using this model, we can emulate the vehicular ratio within the signal coverage via the Frequency Emulation Module and analyze the TCP/IP capability of IEEE802.11n in a Vehicular Internet Environment. According to the result of experiment, the TCP/IP capability of IEEE802.11n is optimal in the low-rate Vehicular Internet Environment. The capability analysis result proved that the proposed Capability Analysis Model of IEEE802.11n not only can be applicable under the Mobile Networking Architecture, but also provide a valuable reference for the Mobile Wireless Broadband Industry.

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