Navini Networks, specifically Sai Subramanian, Director of Marketing, contacted Mr. Joe Dichoso of the FCC's Office of Engineering Technology in June of 2000 seeking advice on the applicability of the FCC guidelines in the unlicensed 2.4GHz – 2.483GHz ISM band. Navini's purpose was to verify that their interpretation of the rules in Part 15.247 was consistent with that of the FCC. This document is a summary of this discussion and contains important technical information about the Navini Networks system as well as feed-back and concerns from Mr. Dichoso from the FCC.

Navini begins the dialogue by explaining its plan to build a time-division-duplex physically displaced multi-antenna Base Station Transceiver complex using spread-spectrum technology for this unlicensed band. The Tx/Rx subsystems are explained below.

Tx/Rx Subsystem Description

The smart antenna spread spectrum transceiver subsystem contains multiple (N) spread spectrum (CDMA) antenna and transceiver units as shown below in Figure 1(a). The antennas of this system will be collocated and will share some downstream processing. It should be noted that multiple transmitters DO NOT share a common amplifier. Each antenna transceiver system contains an antenna receiver subsystem and a transmit subsystem. Each antenna receiver subsystem is comprised of an antenna, a transmit/receive switch, and a receiver. Each antenna transmit subsystem is comprised of an antenna and the same (as receive) transmit/receive switch, a power amplifier, and a transmitter. The block diagram of each unit is shown in Figure 1(b). The operation of each subsystem is described below:

1. Receiver:
   The antenna receives the RF signal. After passing through the T/R switch, the RF signal is filtered, amplified and downconverted to the IF band. The IF signal is further filtered, amplified, and downconverted into In-phase (I) and Quadrature (Q) baseband signals, which are then sampled by the A/D's and the digital processor (FPGAs or DSPs) despreads the digital samples with multiple pseudo random codes d_1, …, d_m and the corresponding results R_1, …, R_m are sent to other digital processors for further symbol level processing and decoding.

2. Transmitter:
   Multiple digital streams S_1, …, S_n, are sent to digital processors (FPGAs and/or DSPs) which spread each signal S_i, i=1, …, n, by one of multiple pseudo random codes c_i, i=1, …, n and sum up all the resultant spread spectrum signals digitally, and digitally filter them with a pulse shaping filter. The composite In-phase (I) and Quadrature (Q) digital signals are sent to the D/As and then upconverted to the IF band. After amplification and filtering, the IF signal is sent to the RF upconverter to the RF band. The RF will be power amplified, filtered and sent to the antenna through the T/R switch.

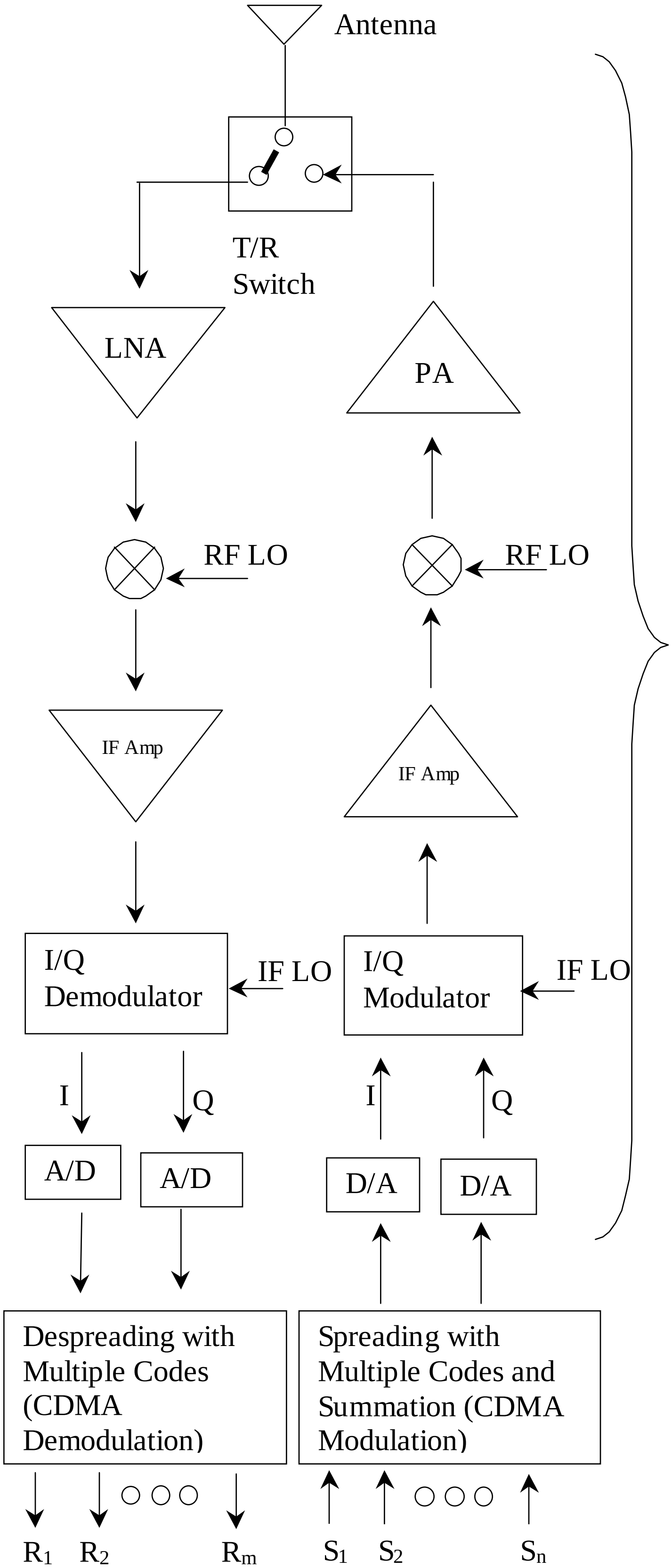

Figure 1(b)

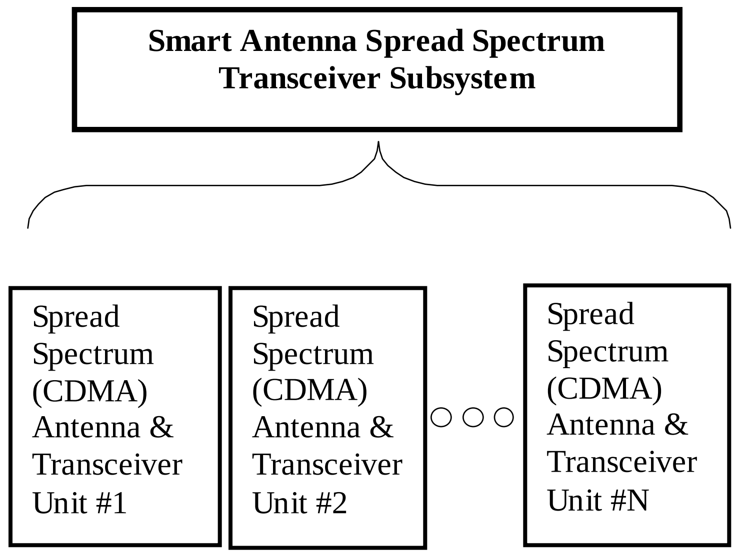

Figure 1(a)

After review Mr. Dichoso had some questions concerning the Navini system, e.g. the actual nature of the S_1, …, S_n signals previously discussed as well as differences between their system and OFDM and traditional Spread-Spectrum devices. Below is a summary of the information relayed in these discussions:

Nature of the S_1, …, S_n multiple data stream signals

- These signals represent a symbol rate.
- The input data rate for each subsystem and the entire system can vary from nX12.5K symbols per second to nX400K symbols per second, where n is a positive integer.
- The combined total bandwidth is at least nX500kHz.
- Each of these signals is a separate signal. Multiple signals may be from/for one user or one signal from/for each user. They are dynamically configurable.
- These signals are obtained from a high rate signal that is split up via serial to parallel multiplexers, therefore a multiplexer should be added in the block diagram seen in figure 1(b). However, the multiplexing scheme is not fixed but variable depending on the user data rate assignment.

Navini System Vs. OFDM

The Navini System is not an OFDM system. Here's a short discussion of the key differences:

In an OFDM system, each symbol is modulated on a narrowband sine wave. Different modulating signals, i.e., sine waves, occupy different narrow frequency bands.

In the Navini system, each symbol is modulated (or spread) on a wide band pseudorandom sequence. All the pseudo random sequences occupy the same wideband frequency band.

Navini System Vs. Conventional Spread-spectrum

We are almost identical to conventional spread spectrum devices except that we transmit the sum of multiple spread spectrum signals modulated (or spread) on multiple pseudo random codes. The Navini modulation method is analogous to that of IEEE 802.11b, which modulates 8 co-channel signals with 8 CCK sequences, except the spreading gain is better. Each symbol in the Navini system is spread by 32 chips thus giving a 15dB spreading gain which is 5dB more than the FCC requirement in part 15.247. Furthermore all the spreading codes are orthogonal and the mutual correlation between any two code sequences is, theoretically, zero which results in no co-channel interference.

After further review and discussion, Mr. Dichoso, from the FCC stated that the system Navini described appeared to be acceptable.