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WIRELESS LOCAL AREA NETWORKS AND HIGH SPEED INTERNET ACCESS VIA SATELLITE FOR PRECISION AGRICULTURE

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Abstract

In taking a systems engineering approach and trying to examine the entire process of remote sensing, image analysis, variable rate prescription generation, on-farm data capture, data and image archival, and information transfer to and from the farm, several bottlenecks are immediately observable. When using satellite collected images, the time from image collection to delivery of the raw image data is too long for practical use in realtime precision agriculture applications. The processing of remotely sensed images so that they can be used in geographic information systems (GIS) such as ARCView and and image analysis software such as Imagine and ENVI is still a time consuming process. The use of fixed wing aircraft for image data collection currently promises to shorten the delivery time to acceptable margins. As technology improves and the need for commercial providers of image capture and image analysis grows, it is likely that the market place will provide some answers to this bottleneck.

A second area of concern is the data communications capability between rural farms and the sites where image analysis and prescription generation occurs. While some farms will have their own capability to perform image analysis and variable rate prescription generation, most growers will choose to have this done by consulting organizations. Even so, the former group will still be delayed in delivering prescriptions to application machinery by having to hand carry media. Thus there are two communications problems to address: (1) remote high speed communications between the farm and service providers and (2) local area networking on the farm.

Currently one of the solutions for data communications between rural farms and service providers is the use of the telephone system and high speed modems. The physical limits of modem technology using copper line is 56 Kbps. The quality of local telephone lines, the central switching systems, and the lines between the two switching systems governs the actual speed which the modem can carry, often much less than the top speed. If the farm happens to be within 18,000 feet of the local central switching system, in the near future access to DSL, digital subscriber line, technology may be available which can operate at 1.5 Mbps bidirectionally. However, since most farms are located further than 18,000 feet, DSL is not an option. Currently there is only one alternative to obtain high-speed data communication economically, and that is the use of satellite technology.

The second side of the communications bottleneck is the provision of local area network capability for the entire farm. Since tractors, pickers, spray equipment, combines, and center pivot irrigation systems move, this precludes the use of wireline system with maybe the exception of the center pivot system. The solution to this problem was the possible use of wireless local area network technology. The Federal Communications Commission has set aside two bands of frequencies for public use for which no license is required. The first band to become available was the 2.4 GHz band which actually ranges from 2.400 to 2.480 GHZ, a total of 80 MHz. However, there are restrictions on the use of this band. The total power transmitted must not exceed 500 milliwatts, and the bandwidth was divided up into discrete bands, which must be accessed used spread spectrum technology. This assured that multiple users could have access in the same area, but at the same time the first users were assured by FCC rule that they had priority and subsequent users must not interfere with prior users. By limiting the transmission power, the range , or size, of each cell, much like cellular telephone technology, was limited to approximately 2 miles line-of-sight. The maximum data rate for this bandwidth currently is 11 Mbps with the multi-channel hopping spread spectrum requirement. The second bandwidth that was sect aside for public unlicensed use was the 5.6 GHz area where the spectrum ranged from 5.600 to 5.900 GHz, or 300 MHz. The new spectrum offers potentially much higher data rate because of the amount of spectrum. However, a single user can use only 200 MHz, and like the 2.4 GHz bandwidth described above this 200 MHz must be divided up into multi channel and digital spread spectrum frequency hopping technology must be used. Equipment for the 2.4 GHz spectrum, since it was made available several years ago is becoming plentiful and relatively low cost, while the 5.6 GHz spectrum equipment is just now beginning to appear in the market place.

To make the use of precision agriculture methodology available and transparent to the grower, there needs to be a high speed data path from the grower's farm to the service provider. Today, large data or image files have to be hand carried from the image analyst to the farm. If this exceeds 1.44 Mbytes, either multiple diskettes have to be used or some other distribution media, which is at additional expense to the grower. Typically image files range in the multi-megabyte size, making data

transmission via telephone modem impractical; first, by the length of transmission time required, and second, by the likelihood of errors to occur in lengthy transmissions causing multiple retries. So, if hand carrying is unacceptable because of travel time and media problems and if telephone modem is also unacceptable, where can we turn? In the fall of 2000, high speed Internet access became available in low cost equipment and service through Starband Communications, Inc. via the Dish Network, Inc. fixed satellite system. A competitive satellite Internet access service has also been announced by Direct TV, Inc.

To test the capabilities of the Starband system, a subscription service was established and equipment procured for the Paul Good Farm located in Noxubee County, MS, a research cooperator. The satellite dish and two way LNB and the transceiver box cost approximately $500, including professional installation which is mandatory. The monthly subscription service was $69.95. The connection between the base computer and the satellite transceiver is via a USB port.

The data transmission rate minimums for the system are 500 Kbps downlink and 150 Kbps uplink. Actual downlink data rates have been observed, using the systems monitoring software, exceeding 1,000 Kbps.

The practical implications of this equipment are that we now can rapidly deliver to the farm base station computer system processed images and generated variable rate application maps from anywhere in the world via the Internet. This also means that farm site data, cultural practice data, actual application rate maps, yield monitor data, and consultants' observations delivered to the grower can be rapidly transmitted to the image analyst and the precision agriculture specialist via the Internet. This means that we, the precision agriculture community, now have the capability with further software programs and drivers to make the delivery and use of application maps seamless and transparent to the grower. This overcomes one part of the information bottleneck and makes the likelihood of widespread acceptance of this technology more possible.

However, we still need to address the movement of information and data on the grower's farm. If it is still tedious to move the application maps to the application machinery and it is still tedious to move farm data from actual applications, consultant forms, and farm records back upline to the analysts, we have a technology acceptance problem. According to Moore (1999), we cannot disturb the grower's operation (or the way he wants to do business) very much or the technology may be rejected.

A solution is to implement a wireless local area network (WLAN), which can connect all of the grower's operations and machinery. The grower needs the option of installing equipment incrementally. Since tractors, pickers, sprayers, spreaders, and combines move in the field, the WLAN must have the capability of handling moving equipment. One such system is the BreezeCOM, Inc. BreezeNET PRO.11 Series equipment. The base station wireless transceiver is shown in Figure 5. This is the BreezeCOM AP-10D PRO.11 D Access Point Enet Bridge. Shown in Figure 6 is the BreezeCOM SA-PCD Pro.11 PCCard with antenna. Together, these two components give the capability of 3 Mbps high speed data communications line of sight up to two miles distance from the base antenna. The AP-10D connects peer-to-peer to the base computer 10-base-T ethernet card. The SA-PCD card is used in the PCMCIA type II slot for the remote equipment.

We have tested this system on notebook computers using MS Windows 95, Windows 98, and Windows 2000 Professional systems software. We have run one two and three SA-PCD systems concurrently with no problems. One must note here that the cumulative data rate of all systems will not exceed system maximum of 3 Mbps. Even so, this capability should be sufficient for the rapid transfer of application maps from the base station computer to the application equipment.

If the variable rate controller or the yield monitor equipment has the capability, the grower can have data transferred from this equipment directly to his base station computer in real time. Center pivot irrigation systems can be equipment with GPS sensors and SA-PCD equipped ruggedized computers so that proper operation of the center pivot system can be monitored remotely with alarms initiated when the system deviates from normal operation.

'Remotely' here really means remotely. Since the entire farm will be under the Wireless Local Area Network, any computer equipped with a BreezeCOM transceiver can monitor any piece of equipment from anywhere on the farm. Furthermore, since the base computer is equipped with the satellite Internet transceiver, any person with the proper credentials from anywhere in the world can do the same. Before one gets concerned about data privacy, we recommend that the base station should be equipped with firewall software such as the Ositis Software, Inc. WinProxy system. This provides complete firewall security for the entire WLAN system. It also allows one account through the Starband network to service an unlimited number of hidden subaccounts, basically acting as a router and providing secure access to the Internet and from the Internet to farm equipment by authorized personnel. Thus through the recent development of new hardware and software technologies, the goal of high speed networking on the farm and connection by high speed to the Internet can now be realized.