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REMOTE INFORMATION MANAGEMENT SYSTEM (RIMS)

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ABSTRACT

This paper proposes a remote information management system, called RIMS, which can be used as an integrated management tool in rangeland livestock industry. With RIMS, activities in widely separated remote sites can be effectively monitored and controlled at a convenient central location, such as the homestead, through the use of a dedicated UHF wide area radio network. Details of all the monitored information and activities can be stored in a central database for later analysis if necessary as part of the productivity management process. The design considerations of the radio network infrastructure are discussed in this paper.

INTRODUCTION

Agriculture is perhaps the most extensive form of land use representing about 59% of the total land area of Australia (ABS 1998/99). There are over 140,000 Australian properties involve in agricultural activities, such as meat and dairy cattle grazing, sheep farming, grain growing, and even mixed grain/sheep/beef farming. Most of these properties are often very vast occupying thousands of hectares. A major challenge in managing an enormous animal grazing property is the large amount of time spent on regular mill runs to carry out routine inspections of remote key locations such as watering points. It is well recognised by livestock producers that a great deal of management efficiency could be achieved if it is possible to minimise such time consuming and costly mill runs. In many cases, innovative technology is available to assist producers do many routine tasks more easily and cost-effectively.

The adoption of new technology by livestock producers over the years has been slow and sporadic. A main reason of this is that most new technologies are perceived by livestock managers as being disjointed and not cost-effective alternatives to existing practices. Consequently, very little technological advances have been made in rangeland production systems in recent decades. In fact, it could be argued that mustering by light aircraft was the last great advance in technology adopted for reducing input costs and increasing productivity. With the rapid progress in communication and information technologies in recent years, it is now appropriate to apply some of these modern techniques to enhance the management process in the grazing industry. This is especially relevant if the industry were to remain profitable and sustainable within the context of global competition.

The areas of greatest interest for the livestock industry in rangeland are the efficient use of water, and the adoption of automation, which is likely to improve the rural lifestyle by doing away with some of the manpower intensive routines. The latter leads to the use, albeit on the small scale, of radio telemetry for controlling simple tasks, such as switch on and off of water pump in a remote water point. In this case, a purpose built system may be put together using some off-the-shelf components. Such an ad hoc approach may satisfy the immediate need but is unlikely to support future additional applications and more sophisticated features without major system reorganization and even replacement.

Instead, a systematic approach will need to be adopted to effectively introduce modern management technology to the rural grazing industry. As with any management practice, essential information needs to be collected first, followed by data analysis and decision making before any appropriate action can be taken. Now, consider applying this scenario to a rural grazing property covering a vast area remote from mainstream telecommunication infrastructure. In this case, a cost-effective wireless communication infrastructure is necessary for collecting the essential data from the various remote sources through a process called data acquisition. Depending on the nature of the data, it can either be acted upon immediately or stored for analysis later. This calls for a flexible database for proper archiving of the collected data. Often, actions are needed in response to the observed data. For example, when a sensor detects the water in a dam is falling below a preset level, this remote monitoring data is transmitted back to the homestead. As a result, a remote control signal can be activated from the homestead to switch on the water pump either manually by a human operator or preferably through an automatic process. The advantage of the automatic process is that it can take place at any time of the day and the details can then be stored in the database for inspection at a convenient time. More importantly, such an automation process will free the livestock manager from routine inspection tasks to attend to other more crucial production management matters.

Since the wireless communication infrastructure is the key to any remote information management process, its operation has to be very reliable even with minimum maintenance, often in harsh climatic conditions. For this technology to be widely embraced by livestock managers, it is important to keep both the capital and operating costs of the communication infrastructure to a level, which enables a positive return to their investment within a reasonable period. Since in a remote property, the only likely commercially available communication infrastructure is through satellite communications. The use of such an infrastructure will incur recurrent charges, which may be prohibitively high as more remote applications are being introduced. A more attractive alternative may be for a property owner to establish and operate a low-cost terrestrial wireless communication infrastructure. In this case, no ongoing network access charges will be incurred, and the owner will have more control on the ways the infrastructure may be used. Nevertheless, for the terrestrial infrastructure to justify and hold its investment value, it needs to cater for a diverse range of applications, such as video surveillance or even voice communication in addition to remote monitoring and control. Preferably, all these applications can be implemented using a standard set of modular components. The ability to add applications and features must be a key design criterion of the communication infrastructure. As it is important for the remote property to be in contact with the outside world, any information including compressed images collected from the remote sites may be exchanged via a satellite communication link from the homestead.

REMOTE INFORMATION MANAGEMENT SYSTEM

This paper proposes an integrated management tool, called remote information management system or RIMS, which aims at improving the efficiency of managing a vast rural grazing property, particularly to do away with the need of traveling around the property to carry out routine inspections and repetitive tasks at various remote sites. Eventually, it hopes the use of RIMS will not only enhance the productivity of the property but also improve the lifestyle of the people involved in running the property.

With RIMS, activities in widely separated remote sites can be effectively monitored and controlled at a convenient location, such as the homestead. Details of all monitored information and activities can be stored in a central database for later analysis if necessary as part of the productivity management process. In broad terms, RIMS consists of two key components; namely a terrestrial UHF wireless communication network and a central control station which hosts the main database of the system in a personal computer. The design considerations for the communication network will now be discussed.

The backbone of RIMS is a terrestrial wide-area wireless communication network based on the following design considerations:

- Integrated transmission of data, compressed images and voice
- Large coverage area
- Low density traffic environment
- Reliable operation
- Low cost.

The proposed UHF radio network will operate in an unlicensed frequency band, either at the 500 MHz citizen band or the 900 MHz ISM band as many components and radio transceivers are commercially available for these frequency bands. The radio network also has to support an integrated communication for data, digital time-lapsed images and voice over the entire property. It is envisaged that an effective data rate of 32 kb/s will be needed by the system to provide good quality voice and efficient image transmission. Such a data rate can be readily realized without excessive development costs. This is consistent with the philosophy of not to over specify the system unnecessary, especially in view of the expected low mean offered traffic rate encountered in a rural gazing property. Moreover, this data rate is already many times higher than what is presently used in remote telemetry in the rural grazing industry.

One of the main considerations in the design of a radio network is its topology, which is influenced by factors, such as the coverage area, local terrain, and allowed effective radiated power. For the type of applications considered in this paper, the simplest and perhaps the most economical network topology will be one which has a direct link from the homestead to multiple remote locations. In this case, it assumes that the allowed transmit power is sufficient to achieve the required communication quality over the maximum distance separating the transmitter and the receiver. However, a single hop link is often not long enough to cover the required distance. In this case, one or more intermediate links may be provided through the use of repeaters, which then increase the cost of the network. Usually with a careful study of the terrain of a given rural property, it possible to reduce the number of dedicated repeater stations by making use of the transceiver on a remote site to relay the signal to another remote site. For example, as shown in Fig. 1, remote site 2 uses the remote site 1 to act as a repeater for its connection to the homestead. This practice can lead to a significant cost saving.

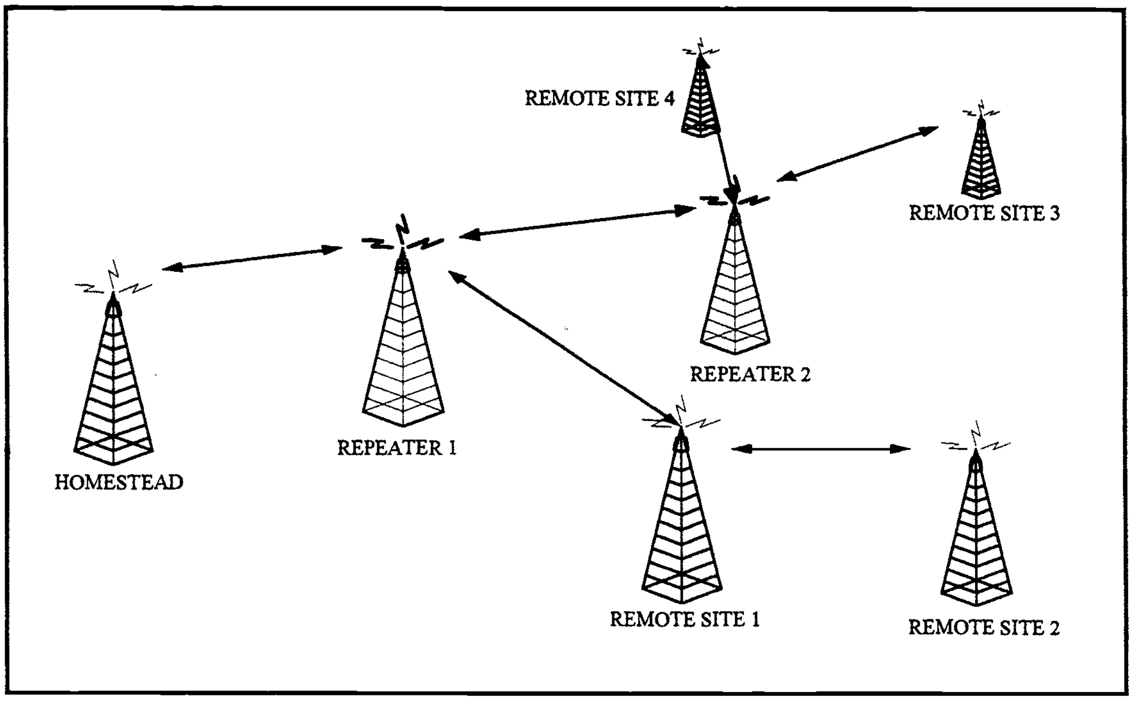

Fig. 1 A radio network topology using a remote site to also act as a repeater station (Palipana 2001).

Another crucial consideration in the design of the communication network for RIMS is the multiple access protocol, which determines how all the transceivers in different remote sites are able to effectively share the common allocated spectrum. This can be achieved using either a centralized or distributed access control scheme. An example of centralized control is the cyclical polling method with which the master station, usually based in the homestead, polls each slave station located at a remote site in a round robin fashion. Such a scheme is simple to implement and is particularly attractive if the number of remote stations is small. As the number of remote stations to be polled increases, the cycle time can be excessive especially when a station has much information to be sent. However, this can be avoided by adopted a modified scheme which allocates a fixed time to each remote station during a cycle. The actual time interval used will be determined in large part by how long a real time voice conversation is expected to last.

On the other hand, a distributed random access technique, such as carrier sense multiple access (CSMA), may offer greater flexibility in an application involving many remote stations. With CSMA, information packets are transmitted only when the channel is sensed to be free from usage by another transmitter. In an event of a collision, information packets need to be retransmitted. Generally, the implementation of such a multiple access scheme is more complicated than a polling scheme.

In the proposed radio network, the data derived from the various peripheral devices, such as sensors, actuators and cameras are to be multiplexed or combined together to form a single information stream to be handled by a single radio transceiver located at each remote site. This practice is effective in terms of cost and spectral utilization for handling a large group of individual peripheral devices, which are generally of low data and/or traffic rates, located on the same site. Furthermore, it offers a greater flexibility in device interchangeability without affecting the operation of the radio network in any way.

The next important consideration for the design of the wide area radio network is the link budget, which determines the radiated power and receiver sensitivity required to achieve a specified performance measure, e.g., a maximum allowable bit error rate (BER). The link budget is greatly influenced by the path loss incurred by the propagation channel. As an exercise, a realistic estimation of the radiated power level required for achieving a good quality communication link in a rural property has been obtained using the Okumura empirical formula for path loss calculation in a quasi open area (Jakes 1974). Table 1 tabulates the combined levels of effective radiated power and receiver antenna gain, i.e., (*ERP* + *Gr*) expressed in *dBm*, required for achieving different communication distances with various antenna heights at a carrier frequency of *500 MHz*, and *900 MHz*. The receiver sensitivity is assumed to be *–100 dBm* for a maximum allowable bit error rate of 10^{-3}.

Table 1 Combines levels of effective radiated power and receive antenna gain

Tx-Rx distance (*km*)	1. Carrier freq = *500 MHz* (*ERP* + G_r) *dBm*				2. Carrier freq = *900 MHz* (*ERP* + G_r) *dBm*			
	$H_t = H_r$ = *10 m*	*15m*	*20m*	*25m*	$H_t = H_r$ = *10 m*	*15m*	*20m*	*25m*
10	*29.0*	*25.5*	*23.0*	*21.1*	*33.2*	*29.6*	*27.0*	*25.2*
20	*37.7*	*34.1*	*31.6*	*29.7*	*42.1*	*38.6*	*36.1*	*34.1*
30	*45.2*	*41.7*	*39.2*	*37.3*	*49.7*	*46.2*	*43.7*	*41.7*
40	*52.2*	*48.7*	*46.2*	*44.2*	*57*	*53.5*	*60.0*	*49.0*
50	*58.3*	*54.8*	*52.3*	*50.3*	*63.0*	*59.5*	*57.0*	*55.0*

Table 1 shows that a communication distance of *20 km* is achievable using a *1 W* transmitter in conjunction with a *3 dB* antenna for both the transmitter and the receiver. This assumes that the antenna height is *15 m* for operation at *500 MHz*, and *20 m* at *900 MHz*.

CONCLUSION

A remote information management system, called RIMS, has been proposed specifically for application in rangeland livestock industry. As a management tool, RIMS can assist in enhancing productivity as well as improving the lifestyle of people running the rural grazing property. This paper has also considered the major factors concerning the design of a wide area wireless communication network, which is the key component of RIMS. It is shown that a communication link of 20 km is feasible with a low power transmitter operating at either *500 MHz* or *900 MHz*. A detailed discussion on the design of a digital radio network for wide area coverage is presented in (Palipana 2001).

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