AUTOMATED REMOTE DATA ACQUISITION 1/

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By

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Introduction

Ever since man decided that there was valuable data to be acquired from remote locations he has been striving to automate the acquisition of that data. Early attempts at this automation were characterized by high cost and questionable reliability. With the advent of highly reliable solid state components, this picture has changed in recent years to where several reasonable alternatives for automated remote data acquisition exist. The writer's purpose is to present a methodology for determining the optimum components comprising an automated remote data acquisition system from the available alternatives.

Basic Remote Data Acquisition Elements

Every remote data acquisition system consists of four basic elements. For this discussion, these elements are labeled data sensing, data transmission, data processing, and data delivery. These elements are not always physically distinct but are functionally separate. These elements are defined as follows.

Data Sensing - This is the method of converting an unknown physical remote quantity to an electronic signal.
Data Transmission - This is the method of transmitting remote electronic signals from a remote location to a readily accessible base station.
Data Processing - This is the method of converting transmitted electronic signals into useful information with attendant storage and retrieval capabilities.
Data Delivery - This is the method by which the user communicates with the system for both control and information retrieval.

Before proceeding with the selection process, the current application to be automated should be examined with respect to how the four basic elements are currently being satisfied. If current methods are adequate, automation is probably premature. If not, one must be convinced that automation is feasible. The answer to this is an equivocal "yes." Data sensing devices are field proven; successful prototype and operational transmission systems are in existence; data processing and delivery systems proliferate all industries and are well within the state-of-the-art.

Design Determinants

User requirements and the physical properties of the application dictate the system design determinants. The major design determinants of an automated remote data acquisition system are remoteness of data sites, frequency of sampling, real time responsiveness, data accuracy, the number of parameters per data site, and the total number of unique data sites. These design determinants are described below without regard to their relative importance which is dependent somewhat on the application.

Remoteness of Data Sites - This consists of data site accessibility, local topography and environmental conditions.
Frequency of Sampling - This is the most frequent sampling rate of an individual parameter anticipated at some time during the life of the system.
Real-Time Responsiveness - This is the minimum delay time tolerable for the time a parameter is measured to when it is available to the user.
Data Accuracy - This is the minimum acceptable error allowed in the measurement of individual parameters.
Number of Parameters Per Data Site - This is the maximum number of distinct parameters to be measured at one data site during the life of the system.

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Number of Data Sites - This is the maximum number of individual data sites anticipated during the life of the system.

The system requirements as defined by these design determinants have a major influence on the selection process necessary for automation.

The Critical Element

In every automated remote data acquisition system there is a critical element as dictated by the design determinants. This critical element is identified utilizing a weighted matrix showing the relative effect of each design determinant on the four basic elements of the system. As shown in Figure 1 this weighting process identifies the critical element as data transmission with the next most critical element being data sensing. Each of these elements is relatively independent of the other and is evaluated as such. Because the transmission element represents a total commitment in design principle it requires special attention.

	SENSING	TRANSMISSION	PROCESSING	DELIVERY
REMOTENESS	3	5	0	0
FREQUENCY	2	5	1	1
RT RESPONSE	1	5	1	5
ACCURACY	5	3	2	0
NUMBER OF PARAMETERS	3	5	1	1
NUMBER OF SITES	0	5	2	1
TOTALS	14	28	7	8

WEIGHTING FACTOR 0-5

FIGURE 1 - THE CRITICAL ELEMENT

This is not to say data sensing is unimportant, but changes can be made to the sensing element during the life of the system on an individual parameter basis with minimal impact on the overall system. Therefore, the transmission element selection process is of major concern with a similar and parallel effort being used for the data sensing element selection.

The Transmission Candidates

The major candidates for satisfying the critical data transmission element are land lines, radio frequency (RF) line-of-sight, meteor burst, orbiting satellites, and geosynchronous satellites. Each of these candidates have been field proven in operational and prototype systems. Operationally, they fall into the category of an interrogated system or a timed transmission system. An interrogated system is one where a polling sequence is originated at a base station and requires a duplex data path. A timed transmission system is one where the remote component transmits at a predetermined and fixed frequency and requires a simplex data path only.

Land Lines - This transmission medium is either a timed or interrogated system and is characterized by physical wires from a remote location to a base station.

RF Line-of-Sight - This medium uses VHF, UHF or microwave radio frequency transmission. This is an interrogated system requiring one or more discreet line-of-sight paths from a remote location to a base station.

Meteor Burst - This medium uses ionized trails of micro-meteors entering the earths atmosphere as reflectors for VHF transmission between remote stations and base stations. This is an interrogated system using random reflected radio paths that occur on the average of 5,000 per hour (greater than or equal to .06 seconds duration) for communications between two points up to 2000 kilometers a part.

Orbiting Satellites - This medium uses satellites orbiting the earth from pole to pole as a UHF repeater creating useable data paths whenever the satellite is within line-of-sight of both a remote location and a base station. This is a timed system.

Geosynchronous Satellite - This medium uses satellites that are in an orbit synchronized with the earth's rotation so as to remain over a fixed location at the equator. UHF data transmission paths are available at all times subject to operational protocol (e.g., Memorandum of Agreement between National Environmental Satellite Service (NESS) and users or agencies.) This medium is either interrogated or timed.

From the above alternatives a selective evaluation process is initiated to determine the most appropriate transmission method.

Qualitative Evaluation Factors

The evaluation criteria for selecting a transmission system are cost, administration, performance, flexibility and risk. These criteria, common to all applications are described in more detail below.

Cost - Total cost includes investment, operation and life cycle costs.

Administration - Program administration includes ease of implementation, personnel impacts, interface with cooperatives, contractual implications, and ease of administrative growth.

Performance - System performance includes data accessibility, system reliability, and responsiveness to user requirements.

Flexibility - System flexibilities include ease of modification, growth capabilities, and ability to absorb more demanding performance standards throughout the life of the program.

Risk - Risk factors include the extent to which the state-of-the-art is being advanced, the impact of uncontrollable factors, and system susceptibility to catastrophic failure.

With the evaluation criteria defined each candidate system is examined relative to the application.

Quantitative Evaluation

The first step in evaluation of transmission alternatives is to eliminate any candidate system that does not have the capability to meet the ultimate system requirements under reasonable conditions. For example, if a system requirement is for hourly readings, a system with a six hour capability will obviously not meet the requirement and is eliminated from further consideration. Next, in depth research is performed on the remaining candidate systems to determine their responsiveness relative to the evaluation criteria. Then the evaluation criteria are assigned quantitative values reflecting program priorities. It is this step that separates one application from another and adds subjectivity to the evaluation. With the relative evaluation criteria weights established, each candidate system is graded relative to the competing systems. Figure 2 represents a hypothetical evaluation of four candidate systems. In the example of Figure 2, one might drop alternative D and possibly A from further consideration and proceed with more in-depth comparative analysis of alternative B and C. This analysis includes the generation of anticipated operational scenarios using each of the candidate systems. By micro-analysis of each alternative within each evaluation criterian a single candidate is then selected. With the key element selected, the system finalization can proceed.

Finalized System

While the critical transmission element is being selected an independent but similar evaluation process is proceeding on the data sensing element. With the two independent elements satisfied it remains to optimize the data processing element to support the sensing, transmission and delivery elements with the delivery element being dictated by the user requirements. This optimization process is an important step in system finalization and although well defined and within the state-of-the-art, it should not be treated lightly. All elements are then integrated into a homogeneous automated remote data acquisition system responsive to the program needs.

CRITERIA		TRANSMISSION ALTERNATIVES			
		A	B	C	D
COST	(50)	50	45	40	35
ADMINISTRATION	(10)	5	10	8	7
PERFORMANCE	(20)	5	17	20	10
FLEXIBILITY	(10)	2	6	10	4
RISK	(10)	5	8	9	10
TOTALS		67	76	87	56

FIGURE 2 - QUALITATIVE EVALUATION

Summary

The decision to automate remote data acquisition is an important step with a permanent effect on the future of a program. Once automation is justified, the process of selecting the appropriate elements of the acquisition system is methodical and thorough. This selection methodology consists of defining the key elements of the system, analyzing user requirements, identifying the design determinants, and satisfying the critical system element through qualitative and quantitative analyses. With the critical elements satisfied, the automated remote data acquisition system is finalized and optimized around the key transmission element into a user responsive system.