Characteristics of automated power system monitoring & management platforms

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Abstract

This paper considers the concept of an automated service dispatch system in the management of dc powering infrastructure. The general characteristics of telco dc power system management are discussed and a model for automated service dispatch is proposed.

Introduction

The storage battery is a critical element in all standby power applications, and the valve-regulated lead-acid (VRLA) battery is now the technology of choice in most telecommunications standby power plant. The operational performance of VRLA batteries is often identified as a risk to the reserve power function. In recent years there has been a substantial degree of technical activity seeking ways to determine and report the condition of the VRLA battery installation. While the most effective method to determine the integrity of the VRLA battery is subject to debate, the usefulness, or *value*, of battery-system monitoring is less controversial. Recording selected battery parameters over time has long been established as an integral component of battery-system management. Indeed, periodic manual measurements of cell potentials and specific gravity formed a cornerstone of historical battery maintenance routines. Periodic monitoring not only provided a formal means to verify design and operational intent, but also additional information about the system upon which judgement about the management of the batteries could be made.

Concepts of data collection in battery and power systems are well developed. The generic characteristics of battery monitoring systems have been widely described and there is now a considerable proliferation of electronic battery monitoring devices in the marketplace [1-4]. However, it must be said that the interpretive and diagnostic ability of these devices varies widely and thus the success of such devices as replacement of traditional approaches is subject to conjecture. Notwithstanding, it is generally accepted that battery monitoring techniques *can* provide valuable information about the battery and power system. In particular, monitored systems can provide crucial operational and functional information during unattended events.

In practice, it is the integrity of the entire power system that is critical for the standby function. The recent trend has been to consider the integration of the operational status of the power conversion and distribution components as well as the energy storage components into a "whole-of-system" functional monitoring [5-8]. The functional approach is advantageous in that it may accommodate the interaction of various components of the power system.

The scope of interaction of power system components is potentially broad, and the complexity of functional monitoring depends on the degree of system information and control required by the application and the operational infrastructure. Therefore, infrastructure management of DC power systems requires functional monitoring to provide sufficiently useful information about the power system to allow efficient and effective decisions. The type of information and decision-set include operational status, risk of function, life-cycle consideration, routine maintenance and event action.

While the technical task of monitoring might be well established, concepts on the dissemination and utilisation of the information delivered by battery and power system monitoring in a formal management platform are considerably less developed. Infrastructure management and operational activities must now occur in the context of cost efficiency and reduced artisan workforce. However, modern approaches to the functional integration of automated data collection, interpretations, and action dispatch have not yet been widely applied to standby DC power plant.

Network and content convergence provide new opportunities to establish low-cost automated dispatch of product and services. E-commerce over the Internet is a particular example. Many of the infrastructure management and operational maintenance activities of *telco* DC plant are no less applicable to the productivity and performance improvements possible with automated process over convergent networks. This paper considers the possibilities that emerge from network and content convergence when applied to power system infrastructure operation and management.

Service supply model

In a simple form, the supply of a service entity can be modeled as interaction between two parties through some form of interface *agent*, as shown in *Fig 1*. Note that either party can act as either the origin of the service (service provider) or the receiver of the provided service (service consumer). By definition, the provider responds to a service request from the consumer. The agent is a means or mechanism to facilitate the transaction. In many cases, the agent may be an integral part of either the provider or customer system, or it may be a separate entity.

Fig 1. Basic service relationship

In any implementation of this basic model, a minimum level of information about the parties and the required service is necessary for any transaction. For an automated dispatch service environment, the required information must be in an accessible database form.

Telco DC powering

To explore the possibilities of automated service dispatch in the telco powering domain, it is first important to appreciate the DC power infrastructure elements. The traditional telco service model can be represented as shown in *Fig 2*.

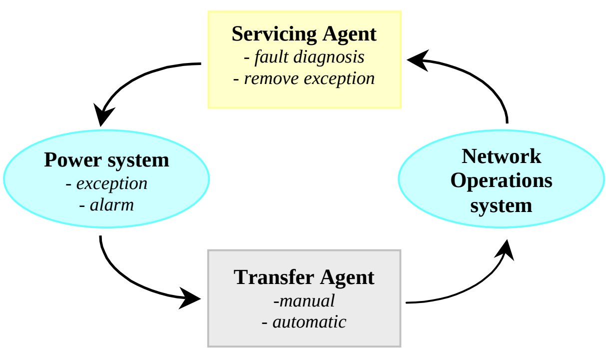

Fig 2. Traditional telco power system servicing model

In general terms, the operational status of the power system is assumed to be normal unless indicated otherwise by an exception indicator. The exception indicator is a form of request for service. Thus, in the traditional environment of a telco operator, the power system might encounter an operational exception and raise an alarm. Alternatively, a physical inspection of the status of the system components as an element of routine maintenance activity might detect a faulty component. In either case, the exception condition is transferred to the network operations infrastructure system. In historical terms, the service request would have been initiated through manual intervention.

Thus, a defect report mechanism would ultimately request a service action in response to the exception. A service technician would be dispatched to resolve the cause of the extended alarm, or address the defect. The service exercise would either be completed or, if the required corrective action could not be completed, the fault condition would effectively escalate, and further works requested. The outcome of the entire action was typically reported back to the infrastructure of the network operations system by paperwork and updating of records.

The *telco* power system infrastructure is characteristic in that the degree of exception reporting is rudimentary. The number and types of alarms used by different *telco* operators varies to some degree, but in essence, the functional information conveyed to the network managers by extended alarms is extremely basic, *viz*:-

- Bus overvoltage
- Bus undervoltage
- Rectifier abnormal
- Rectifier failure
- Distribution elements "off-normal"

While the alarm carries minimum information about physical circumstances which might be a risk to the functional purpose of operation, there is virtually no information useful for the management of the types of services which might be required to efficiently attend to the actual service request. A move to automated operational maintenance platforms for *telco* DC power infrastructure requires a substantial increase in the value of the information content value provided by the monitored performance indicators.

Functional Monitoring

In a co-operative, interactive, component system, the quality of the overall output function may be continuously assessed. In all systems involving some form of feedback, functional assessment is a core role of the control function. When conditions occur which represent a risk to the function of the system, the assessed risk may be self-handled by the system as part of a self-regulation and control process. Additionally, the risk may be reported as control or management information to an external system. The general characteristic may apply at one or more component sub-levels comprising the system function through to the overall system *purpose*. The sub-level processes all have an identified link, or contribution, to the entire outcome.

The temperature-compensation of float voltage control in *telco* rectifiers is an example of co-operative monitoring of at least two aspects of components of the DC standby power system. The temperature compensation function is an element of a set of processes and circumstances deemed necessary to help ensure the overall system function of supply of storage energy, on demand, into a load. At the local control level, the temperature compensation of float voltage is self-administered, and in normal operation, there is no need for the local operation to advise externally of the task. However, the information could be made available if the operation proved to be abnormal, and was deemed to threaten functional output of the system (*i.e.* emergency power). It may also be appropriate that the information be made available to a request for such information from an external source such as a network manager.

Therefore, in terms specifically aligned to telco powering, functional monitoring can be best considered as intelligent exception reporting. The general scheme is shown in *Fig 3*.

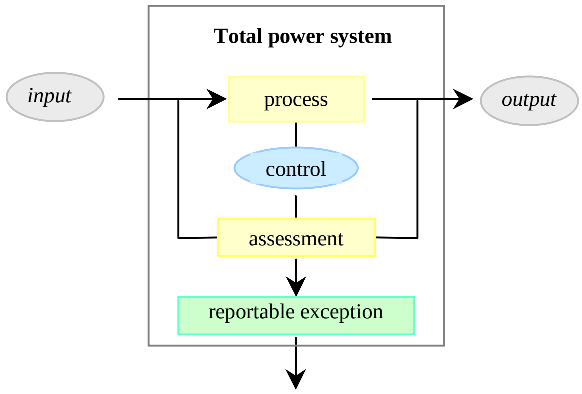

Fig 3. General scheme for local functional reporting

In contemporary telco power plant, feedback and control functions are generally restricted to the local component operation. That is, there is no end-to-end feedback or control loop collectively across all the components that make up the entire power system. Functional monitoring provides a simple and elegant means to apply an end-to-end control function to the entire system. Thus, localised control of the entire power system functionality is possible. For example, a high impedance battery cell could force rectifier current limit (say, to prevent thermal runaway). Furthermore, in a distributed network system with connectivity to a centralised management centre, functional monitoring provides a simple means to accommodate broadcast system control.

A necessary requirement for intelligent exception reporting is a means or process to order and prioritize the various contributions to the determination of risk to function. This demands a degree of self-diagnostic assessment capability. The degree of local "intelligence" must be sufficient to determine abnormal operational and performance conditions. Rule-book approaches are typically used when prioritised decisions (and actions) are required. Rule-book approaches require identification of all the elements which contribute to the functional output. Thus, as shown in *Fig 4*, functional monitoring requires a local process to logically determine the true status of the power system with respect to risk to the output functionality.

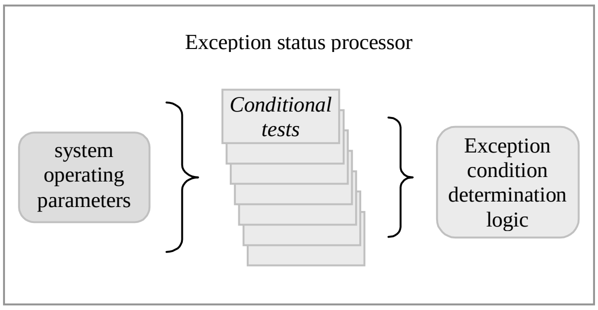

Fig 4. Local intelligent exception determination

Functional monitors in the dc power system plant would provide a means to support the basic service model of *Fig 1*. Intelligent power system monitors would provide sufficiently valuable information to a network manager to enable useful service transactions to occur.

However, the scope of capabilities in battery and power monitoring systems currently available is quite varied. Most are not functional monitors and very few support rule-book approaches to self-assessment and exception reporting. Battery monitoring systems that operate under continuous surveillance mode must rely on an external data collection agency to process information and determine status condition. Yet, in many other domains, the technology to achieve the level of monitoring, self-diagnosis, and reporting is relatively common-place and low-cost. There does not appear to be any impediment to evolving telco dc power systems towards intelligent exception reporting.

If intelligent power system monitors were integrated into the power system plant, a form of automated service dispatch and management control could be readily proposed. Ideally, the operation of the power system monitors should be configurable and adaptable. Configurable systems accommodate installation variations throughout the network.

Automated Service Dispatch System

A simple Automated Service Dispatch System (ASDS) is outlined in *Fig 5*. It consists of a centralised Automatic Dispatch Platform (ADP) which services one or more remote DC power systems (RPS) distributed through a network infrastructure. The RPS are equipped with functional monitors and are capable of intelligent exception reporting, self-assessment, and control. The direct relationship between the RPS and the ADP is augmented by the Remote Contractor. In terms of the model, the Remote Contractor is an agent capable of facilitating service requests unable to be achieved directly between the ADP and the RPS. In practical terms in the telco powering domain, the Remote Contractor is the agent contracted to physically carry out specific works on the power system.

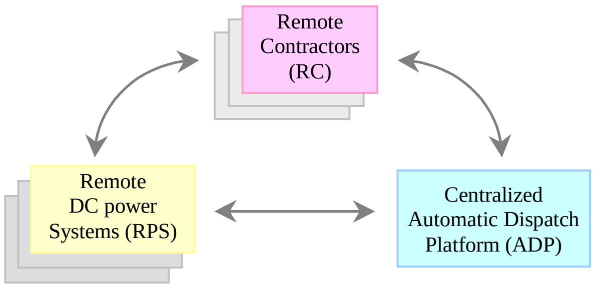

Fig 5. Elements of an Automated Service Dispatch System

In operation of the process, the ADP is responsible for issuing all forms of service requests to the Remote Contractor. The causal reason for the service order may originate as a result of an exception report from a RPS, or from scheduled routine life-cycle maintenance requirements. The ADP therefore has the functional role to prioritise the service task list for each RPS. The ADP can support one or more Remote Contractors. The RC has the minimum requirement to be able to interface into both the ADP and the RPS technology.

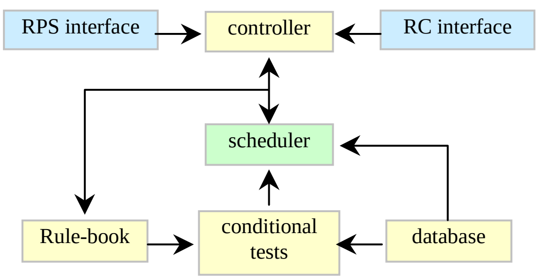

Fig 6. Elements of the ADP

Computationally, the ADP has elements similar to the RPS. Fig 6 shows the basic elements of the ADP. The operation of the ADP originates from a rule-book of conditional arbitration. As with the RPS, the practicality of the entire Automated Service Dispatch System is considerably enhanced if the ADP component is both configurable and adaptable to accommodate variations with network infrastructure.

Drivers

There are many drivers for automated service dispatch and management control across distributed operations. In traditional telco powering infrastructure, the primary drivers are :-

- operating costs
- functional reliability
  (performance confidence)

In many telco environments, capital cost issues are addressed by “cheapest quote for minimum performance” approaches while operating costs are typically reduced by processes of de-skilling, staff reductions, and curtailing life-cycle support strategies. It is probably apt to say that it is often false economy because the former usually requires increased commitment to the latter.

Deregulation and the growth in the telecommunications markets also allow new operators. New operators do not carry legacy infrastructure, and tend not to build up an artisan labour force. Rather, new operators tend to adopt contract operations and management arrangements. The concepts of an Automated Service Dispatch System provides potential benefits in terms of :-

- Management efficiency
- Contractor management

The ASDS provides a means for low-cost contractor performance metrics and management. Contractor activity is initiated by the ADP. The contracting agent can be required to receipt the service request as an element of responsibility, or indeed, a receipt may be required before site access for works is granted. Completion of the service request at the remote power system by the contracting agent can be automatically receipted by the intelligent monitor at the RPS. The ADP can then determine the true mean-time-to-repair. The potential for the ADP to provide contractor performance audit is attractive in the present marketplace.

Data Transfer options

The management platform requires information transfer between the RPS, RC, and the ADP. Computationally, the control model does not require or dictate any particular form of data transmission medium or methodology. However, in practical terms, the system would need to accommodate a range of digital communications options:-

- Wireless- GSM, micro-cell
- Telephony – modems, ISDN
- Networks (LAN/WAN/Internet)

The viability of a given communications method depends on the scope of application, and the boundary conditions which might apply in a given telco infrastructure. Clearly, the type of communication chosen establishes the hardware and transfer protocol that must be supported by both the RPS and the ADP. However, connectivity between different data transfer technologies is increasingly assured, and thus the communications platform becomes increasingly irrelevant. Internet-based approaches allow for widest distributed access, while network-specific data transmission services provide more secure and controlled–access capability.

Conclusion

Automated service dispatch and management control is an emerging area of commerce that results from low cost computing and convergence of data transmission technologies. Improvement in the operation and management of dc powering infrastructure may be achieved by moves towards automated processes for the delivery of the standby power function. In principle, the telco dc powering infrastructure does not have any peculiar characteristics different from other areas of engineering commerce which would prevent considerable degree of integration. However, the existing methods of managing both the operation and life-cycle procedures are insufficient to allow migration to cost effective, automated platforms. A considerable degree of "intelligence" needs to be assimilated into the power system monitoring and control. Identification of the elements of the power system operation which contribute to the functional purpose of the standby application is also needed before rule-based control and dispatch processes can be implemented.

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