MULTISITE CONTROL CENTRES FOR MORE RELIABLE DISTRIBUTION MANAGEMENT

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ABSTRACT

Dual control center (CC) configuration, i.e. main CC and emergency backup CC connected by means of inter control center communication links, is a classical concept to overcome the outage of an entire CC. However, there are various drawbacks that limit the usability of these concepts such as insufficient backup of operational data, duplicated effort for data maintenance, and investment in the backup CC that cannot be used during normal operation. The paper presents the concept and technology of an improved multi CC setup. So-called Multi-Site configurations include the capability for setting up dual CC configurations that overcome the previous drawbacks. Beyond that, Multi-Site configurations allow temporary shifting of the operation responsibility of designated distribution network areas between CCs during crisis situations in order to avoid overloading the staff of affected CCs.

INTRODUCTION

In order to provide sufficient control availability the main components of a SCADA/DMS installation, e.g. servers, normally are redundant. Components that process real-time data are operated in a hot-standby mode that allows fail-over within seconds; other servers are operated in kind of warm standby with failover times of some minutes.
In order to gain increased control availability, more and more utilities consider the installation of a backup CC. A backup CC is used for the control of the distribution system in case the main CC is severely damaged or for any reason inaccessible. Traditional concepts include two separate CC installations – each with redundant components on its own - where the backup system database is synchronized in regular intervals, e.g. once a day, and dual-ported RTUs are connected to both locations. In these concepts operator entered data such as manual switch updates or acknowledgements are not transferred to the backup CC.
To overcome these drawbacks and in order to achieve some more operational benefits the concept of Multi-Site CCs was developed: Several autonomous CCs work together - even from different levels of the control hierarchy - as a homogenous set of CCs - with online activation of data base change from a single (!) place across the entire set.
In the following first the technical principles of the Multi-Site technology are described followed by an outline of some major configurations based on the distinctive configuration flexibility of the Multi-Site technology. The benefits from Multi-Site solutions are explained with the help of real CC projects.

MULTI-SITE TECHNOLOGY PRINCIPLES

First of all, Multi-Site technology applies to a set of CCs. There is no limit in principle on the number of CCs in the set. Even though being part of a Multi-Site configuration each CC in the set is an independent self-contained CC installation i.e. it can continue working properly if communication links to other CCs in the set fail.
Secondly, Multi-Site technology becomes manifested in dedicated software modules that are tightly integrated with the other software modules of the SCADA/DMS of each CC in the set. In this sense the Multi-Site software is an application that controls much of the data traffic within a CC system and with other CC systems of the set. This is done on the level of logical links; data traffic on physical links is not affected.
The aims and features of the Multi-Site technology are:

- Common data maintenance from one central place
- Free exchange of data (real-time or operator entered) between the CCs as configured in each case
- Management of the network from different CCs
- Common process but different process view and sensitivity
- Delegation of system management tasks
- Increased availability

In order to understand how these aims and features are achieved it is necessary to first define some basic terms and concepts of the Multi-Site technology:
Not every CC in the set is monitoring/controlling the complete distribution system at a time. Therefore Multi-Site maintains specific data points up-to-date at specific CCs; these data points are called „Available Points“. The set of all available points at a CC is the so-called **“Information Area”**. This concept reduces traffic on communication lines and the load of real-time data processing. Information Areas of neighboring CCs can overlap; in the special case of a main-backup configuration, for instance, they overlap completely.
Some data might be required in a CC for being processed by an application but not for being visualized to the operator. The **“Viewing Area”** is that part of the Information Area that actually is represented in alarm lists, network diagrams, archives etc.
Within the Multi-Site set of CCs it is necessary to provide process data from the Information Area of a CC to other

CCs. The Multi-Site software manages the according distribution of data between CCs. For instance, process data are transmitted from a substation RTU first to CC A, and from there peer CCs are updated by the Multi Site software. CC A in this case has the **"Data Responsibility"** with respect to the other CCs. The **"Data Responsibility Area"** of a CC is a subset of its Information Area. If an RTU has a physical link to more than one CC all front-end systems will receive messages sent by the RTU, but only one CC at a time is assigned **"Active Master"** for that data point by the Multi-Site system; the Active Master property is defined through the Data Responsibility property of the CC. The RTU links to the other CCs run in listen mode. The active master will process the information and send it to other CCs that have requested that data point for updating their Information Areas. The property "Active Master" is independent of control authority attributes (see below). That means a CC can be active master for a data point without any control authority for that point.

The tasks an operator can perform in a CC are defined via authorizations. A SCADA/DMS typically uses a concept of Technological Areas to assign authorities and responsibilities to users and consoles. Multi-Site, in addition, enables the assignment of authorizations on a CC level. This is done - similar to user authority and console authority - on a per technological areas basis. The entirety of all controllable points is the so-called **"Control Area"** of the CC. Of course, it does not overlap with the Control Areas of other CCs.

The definition of all kind of "Areas" is done by means of the regular Database Management Tool of the SCADA/DMS i.e. it can be adapted to changed operational needs at any time without operation interruption.

It is a design principle of the Multi-Site technology that there is central data maintenance. It is assigned to one dedicated CC (**"Data Model Master Control Center"**). All data model modifications are entered in the source database at the data model master and they are activated to the operational database of the data model master CC at any convenient time. Optionally it is possible – and recommended – to have the changes of the source database transmitted to another CC that is assigned as Backup Data Master Control Center.

If the activation of the data changes to the operational database of the data model master CC was successfully completed, they will be distributed from there to all other CCs. For that purpose, each CC registers at the data model master for data model modifications. They receive a notification whenever a data model modification occurs at the data model master. After that the modified data are requested from the data model master and updated in the respective CC.

The data model modifications are stored temporarily with a version number tracking procedure. After a connection failure or after system run up all data model modifications queued up in the meantime are requested from an appropriate CC and updated in the respective CC until it reaches the same version number. By these means, all CCs have the same and complete data model with formal identical content of information. In particular, each CC knows Information Areas, Data Responsibility Areas, and Control Areas of each other CC.

Each CC in the Multi-Site network has a local data image. Data object identifiers which are unique within the Multi-Site network are passed onto the CCs. By mapping the data points from the common source database onto the local database of a CC via CC specific object functions it is possible to operate CCs with different addressing schemes in a single Multi-Site network.

Communication between the CCs of a Multi-Site network is entirely managed by a layer called the **"Multisite Manager"** which permits access to defined information sources that are not available in the local CC. The multisite manager conceals which server within a control node services the requests from outside i.e. a CC establishes by the availability of Multi-Site services rather than by the status of individual servers or software functions. The Multi-Site managers communicate with each other via the high-speed bus of the Siemens Spectrum Power control center system (Softbus) using TCP/IP.

If a CC has control authorization for a data point, remote control can be performed via the multisite manager beyond CC boundaries. The network control job is passed onto the CC with data responsibility for the particular data point and executed there. Both the controlling and the controlled system perform checks (authorization, interlock conditions, runtime monitoring). As a check-back indication the controlling system receives the status change from the controlled system.

Beyond the basic features listed above the Multi-Site software manages, for instance, the different meaning of tags such as 'alarm inhibit' for the local CC vs. other CCs that also have the particular data point within their Information Areas. Another example for different handling of data points in different CCs are alarm limits settings.

CONTROL CENTER CONFIGURATIONS APPLYING MULTI-SITE TECHNOLOGY

Single-layer

A basic Multi-Site configuration is the interlinking of CCs that operate on the same level of the power supply hierarchy e.g. on the distribution system management level. Such a set of CCs might stem from the fact that several formerly separate utilities have merged, or because the distribution system is too big for being handled from a single CC, or because running several independent smaller CC installations eliminates the risk that comes with the unavailability of a single large CC.

By appropriate – overlapping – definition of the Information Areas it is possible that an operator at CC A takes over the responsibility for technological areas currently assigned to CC B in the same Multi-Site network – all areas or only

selected ones - without leaving his/her familiar working environment i.e. without being forced to use display layouts and operating procedures that are used at CC B. This kind of operation enables leaving some of the CCs in the Multi-Site network entirely unmanned during the night or over the weekend. Similarly, during normal operations operators at CC C can take over some of the technological areas of CC D when the crew at CC D is temporarily overloaded.
In addition, in case CC A is damaged or inaccessible, this configuration allows controlling the network area normally operated from CC A from the other CCs in the Multi-Site network. The only prerequisite is that the RTUs feeding data to CC A also feed their data to another CC in the Multi-Site network.

Main-backup

The Main-backup configuration is a special case of the Single-layer MS configuration. Since the backup CC shall be able to take over the operation of the main CC completely the Information Areas of both CCs must be identical and cover the entire distribution system.

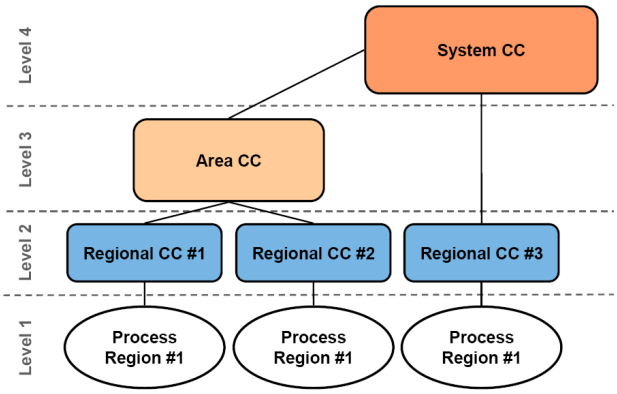

Figure 1: Hierarchical Multi-Site configuration

Hierarchical

A hierarchical configuration as shown in Figure 1 is the most general Multi-Site configuration. Network CCs on the same level acquire process information in parallel and perform their system management tasks autonomously in their respective regions. The CCs at levels 3 and 4 request the process information from CCs at levels 2 and 3, respectively. In such hierarchical structures, because of the differing system management tasks, functions and data are distributed accordingly among the CCs.

REALIZED BENEFITS IN MULTI-SITE PROJECTS

Case 1: Full and immediate backup for network management and data management

This Multi-Site project is currently being implemented for a distribution system comprising 33kV, 11 kV and 6.6 kV voltage levels. The network model includes 200+ substations feeding 20,000 ring main units through 30,000 line segments. The power system has an installed capacity of about 6,000 MW with an annual growth rate of more than 10%. In case of this large DMS, there is exactly the same hardware at both CC locations. This ensures maximum system availability because one CC can replace the other without compromising performance.

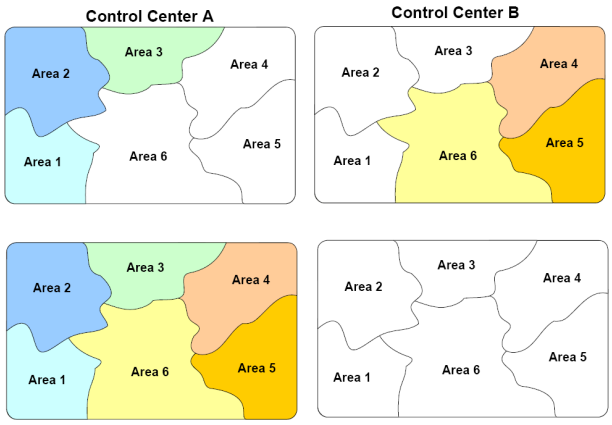

Figure 2: Operation responsibility in normal operation (upper row) and after failure of Control Center B (lower row)

In normal operation, the entire control area is split between both CCs (CC A controls areas 1 through 3, and CC B controls the others (Figure 2). The information areas of CC A and CC B overlap completely. In case a CC, e.g. Control Center A, is unavailable the other CC, Control Center B, takes over control responsibility for areas 1 through 3. This is done by first changing the complete Data Responsibility from Control Center A to Control Center B through an interactive display followed by the transfer of Control Area from Control Center A to Control Center B. The latter activity just means logout/login of the operator in order to take his/her new role. Both activities are done without restart /run-up of the system.
The data model master role is activated in one CC while the other is in data model master backup mode. This applies to both real-time data model and DMS applications data model. Updating between data base locations is done spontaneously so that in case of a failure there is a bump less change to the data model master backup - without loss of any data changes. The whole switchover procedures i.e. change of data responsibility including general interrogation of RTUs plus change of data model master role takes less than 10 minutes.

Case 2: Full flexibility for central, local, and backup control

In this case the Multi-Site system is used for the control of a hydro generation scheme which – due to legal obligations – requires a second way of control with separate process

interface and visualization. Therefore the configuration comprises ten (10) CCs in the Multi-Site set where one is the main CC (SPG) and the other nine (9) are local CCs. One of the local CCs (SHI) covers the backup function for the main CC. All RTUs are connected to main and local CC; important RTUs are additionally connected to the backup CC. The main CC and the backup CC carry the information areas of all local areas, where the local CCs - except for the backup CC – only carry the data of their dedicated region.

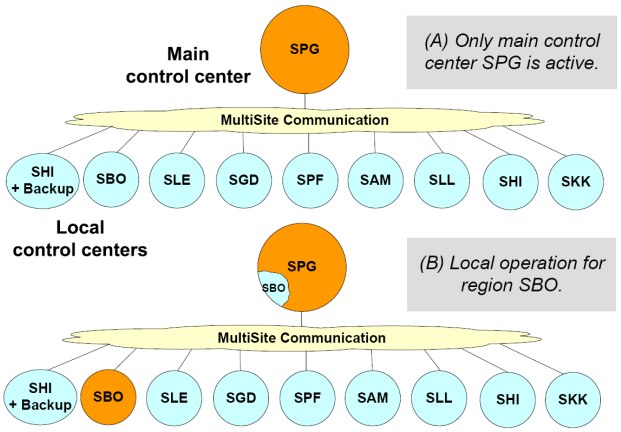

Figure 3: Shift of operation between control center hierarchy levels

During the day, the local CCs can apply the user login 'Control' which changes automatically the control area from the main CC to the local CC (Case B in Figure 3). Then the local CC is master and the main CC - and backup CC - is updated in view mode. For the night when the user 'Control' has logged off the authority changes in the opposite way back to the main CC (Case A in Figure 3).
By using the login 'View User' view mode is also possible in a local CC. This mode does not change any control area settings but shows the operations done at the main CC for the respective region. If no user is logged in at the local CC the list entries and alarm status are automatically acknowledged at the local CC.

Case 3: Multi-level redundancy

In this case the Multi-Site technology is applied to the CC set-up of a company managing the national transmission grid of a European country (Figure 4). During normal operation all monitoring and control is done from the Main CC. The Backup CC works as a full backup for the Main CC (similar as outlined for Case 1). Area CC and Regional CC form additional redundancy levels in case both Main CC and Backup CC cannot access an RTU.

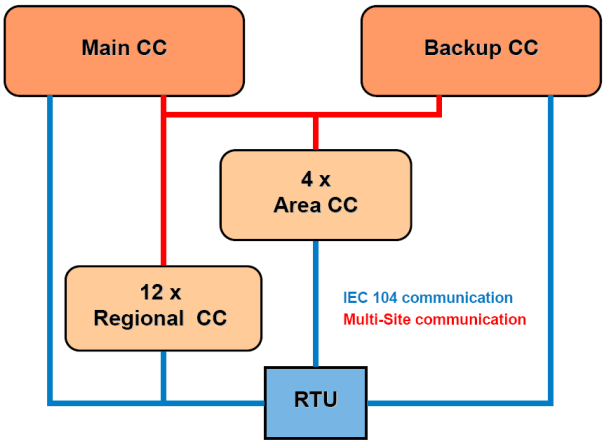

Figure 4: Hierarchical eighteen (18) control center Multi-Site configuration of a European TSO

In order to achieve this multi-level redundancy all CCs shown in Figure 4 form a single Multi-Site set. RTUs are connected via IEC-104 protocol links to their assigned Regional CC and Area CC as well as to Main CC and Backup CC. Normally the data responsibility is with the Area CC; assigned Regional CC, Main CC and Backup CC are updated via Multi-Site technology. Accordingly, a control command travels from the Main CC through the Area CC to the RTU.
If an RTU gets disconnected from its assigned Area CC, e.g. due to a communication line failure, or if the entire Area CC becomes unavailable, the missing process values will be automatically updated from their local process interfaces in Main CC and Regional CC; command output goes directly from Main CC to the RTU. These process values, however, are not distributed across the Multi-Site network. But there is the possibility to switch over the data responsibility from the failed Area CC to another CC e.g. to the Main CC. This provides the opportunity to continue communicating unique process values within the Multi-Site set of CCs - including the one with the disturbed RTU communication line.

OUTLOOK

Projects applying Multi-Site technology have been implemented for the first time in the late 1990's. Since then the technology was continuously improved and has reached a highly mature level. As the next step of development a common archive for all CCs in a Multi-Site is planned. By today, each CC stores messages and values in its one archive. This means that loss of communication to a CC leads to gaps in the archive for those data points that the CC had Data Responsibility for. A common archive would automatically take care of necessary updates.