Objects and Communication Services Modelling for the Automatic Speed Regulator of a typical Itaipu's Hydraulic Turbine implementing the IEC 61850 Standard

by

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Submitted to the Department of Electrical Engineering
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Abstract

Forthcoming.

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Acknowledgments

This is the acknowledgements section. You should replace this with your own acknowledgements.

For example:

I would like to thank to my parents for supporting me though all of this.

Also to Leslie Lamport and Donald Knuth for LaTeX and TeX, without which I would have had much less fun formatting my thesis.

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Chapter 1

Work Research Overview

1.1 Introduction

Energy worldwide is at least a seven trillion dollar a year business and expanding. Energy profoundly affects our economy, society, and environment [2], then, they are a continously researching about new technologies and standards in the electrical power systems, in areas such as information automation, related cyber security and data transfer performance through Smart Grids.

La energía en todo el mundo mueve por lo menos 7 billones de dólares anuales, y es un negocio en expansión. Por ello, la energía afecta profundamente nuestra economía, sociedad y entorno [**?**], debido a esto, existe una constante investigación, y han surgido nuevas tecnologías y estándares en los sistemas de potencia, en áreas como la automatización y tratamiento de la información, por dar unos ejemplos, con el objetivo de mejorar el performance y la seguridad en el sistema de potencia, a través de redes inteligentes (Smart Grids).

In the lasts years, the power systems automation over the world uses microprocessors embedded devices [3, 4] called Intelligent Electronic Devices (IEDs) that suport network communication technologies with the aim of to send or receive information from or to many sources to monitoring, control and supervise the generation, transmission and distribution of the energy.

En los últimos años, la automatización de sistemas de potencia en todo el mundo

utiliza ampliamente dispositivos basados en uno o varios microprocesadores [3, 4] integrados llamados Intelligent Electronic Devices (IEDs) que utilizan tecnologías de redes de comunicación con el objetivo de enviar o recibir información de o para varias fuentes con el objetivo de monitorear, controlar, y supervisar la generación, transmisión y distribución de la energía [5, 6, 7].

The information interchagebility between IEDs from diferent vendors was coming complex, expensive, and sometimes impossible, then the industry

. . . . . .

to adopt the IEC 61850 standard to achieve the interoperability, realiability and more quality for the information interchange of the Energy Management System (EMS).

. . . . . aca debo colocar las siglas de EMS, ver como arreglar este tema para que quede todo bien el tema de las siglas

El intercambio de información entre IEDs de diferentes fabricantes se ha vuelto muy complejo, costoso, y a veces imposible, es por ello que la industria se ha puesto de acuerdo para adoptar el estándar IEC 61850 y así conseguir interoperabilidad, confiabilidad y mayor calidad en el intercambio de información dentro del Sistema de Gerenciamiento de Energía (EMS-Energy Management System).

The IEC 61850 standard "Comunication Networks and Systems in Substations" provide a support for sustainable interoperability between IEDs: information model, information interchange methods, communications protocols mappings and a Substation Configuration Language (SCL) for electrical energy systems (Generation, Transmission and Distribution) for hight, might and low voltage [**?**].

La norma IEC 61850 "Comunication Networks and Systems in Substations" provee un perfecto soporte para una interoperabilidad sustentable entre IEDs: modelado de la información, métodos para intercambio de la información, mapeo a protocolos de comunicación, y un lenguaje de configuración de subestaciones (SCL) para sistemas eléctricos de energía (Generación, Transmisión y Distribución para alta, media y baja tensión) [**?**].

Initially, the standard IEC 61850 focuses on substations, and now it are extended

to

. . . . . satisfacer no se decir..

the totality of the

La norma IEC 61850, en la actualidad, no se enfoca únicamente a subestaciones, también es aplicable y extensible para satisfacer las necesidades de casi la totalidad de la cadena de suministro de energía, entre los cuales destacamos la protección de líneas de transmisión, plantas de energía eólica, distribución de energía y centrales hidroeléctricas, sistemas fotovoltaicos y coches eléctricos [**?**, **?**, **?**].

El modelado jerárquico de la información a través de nodos lógicos es una cuestión clave. La agrupación correcta de los nodos lógicos representan funciones o equipos utilizados en los sistemas de potencia. Cada nodo lógico provee una lista de información bien designada y organizada. Los objetos y servicios definidos en la parte IEC 61850-7-2 de la norma permiten el intercambio de esta información [**?**].

En julio del 2007 las extensiones de los nodos lógicos a centrales hidroeléctricas han sido aprobadas, publicadas y están listas para su uso, en el apartado IEC 61850-7-4-10: *Hydroelectric Power Plants - Communication for monitoring and control*; agregando 60 nodos lógicos y 350 *Data Objects* a la serie IEC 61850 [**?**, **?**].

Este trabajo consiste en la aplicación de la norma IEC 61850, en especial del modelado de nodos lógicos definidos en la parte 7-4-10 Hydro Power Plants y de los objetos y servicios de comunicación para la automatización de una unidad generadora típica de Itaipu, y proponer al TC57 (International Electrotechnical Commission, Technical Committee 57) la complementación o extensión de nodos lógicos de la norma que actualmente son insuficientes para las unidades generadoras de Itaipu. Como estudio de caso, se modelarán los nodos lógicos y servicios de comunicación necesarios para el regulador de velocidad de la unidad generadora. Este trabajo de investigación se basa en el ítem del documento "Proposta de Temas para Monografias de Especialização - Automação, Controle e Supervisão do Processo elétrico Baseado na Norma IEC 61850 - A-4 - Automação de Unidades Geradoras - Modelagem Completa da Unidade Geradora" de la Itaipu Binacional, redactado por Marcos Fonseca Mendes, Antonio Sertich Koehler, Ladislao Aranda Arriola, funcionarios de la Itaipu Binacional.

1.2 Aim of this Research

Blah blah blah

1.3 Research Methodologies and Techniques

Blah blah blah

1.4 Originality of this Research

Blah blah blah

1.5 Organization of this Research Document

Blah blah blah

Chapter 2

Object-oriented programming

2.1 Introduction

This chapter describes the object-oriented programming (OPP) paradigm elements that will be used as the basis for the objects models in the IEC 61850 standard. The chapter does not describe general OPP principles, only focuses on the neccesary principles that will be used on the IEC 61850 engineering.

2.2 Basics of object-oriented programming

2.2.1 Introduction to object-oriented programming

Object-oriented programming (OOP) is a way of organizing the code in a program by grouping it into objects-individual elements that include information (data values) and functionality. Using an object-oriented approach to organizing a program allows you to group particular pieces of information (for example, a automation function or a current value) together with common functionality or actions associated with that information (such as “switchgear actuation” or “voltage measurement”). These items are combined into a single item, an object (for example, an “Album” or “MusicTrack”). Being able to bundle these values and functions together provides several benefits, including only needing to keep track of a single variable rather than multiple

ones, organizing related functionality together, and being able to structure programs in ways that more closely match the real world.

2.2.2 Common object-oriented programming tasks

In practice,

- Defining classes
- Creating properties, methods, and get and set accessors (accessor methods)
- Controlling access to classes, properties, methods, and accessors
- Creating static properties and methods
- Creating enumeration-like structures
- Defining and using interfaces
- Working with inheritance, including overriding class elements

2.3 Classes

A class is an abstract representation of an object. A class stores information about the types of data that an object can hold and the behaviors that an object can exhibit.

2.3.1 Methods

Methods are functions that are part of a class definition. Once an instance of the class is created, a method is bound to that instance.

Get and set accessor methods

Get and set accessor functions, also called getters and setters, allow you to adhere to the programming principles of information hiding and encapsulation while providing an easy-to-use programming interface for the classes that you create. Get and set

functions allow you to keep your class properties private to the class, but allow users of your class to access those properties as if they were accessing a class variable instead of calling a class method. The advantage of this approach is that you can avoid having two public-facing functions for each property that allows both read and write access.

Constructor methods

Constructor methods, sometimes simply called constructors, are functions that share the same name as the class in which they are defined. Any code that you include in a constructor method is executed whenever an instance of the class is created with the new keyword.

2.4 Intefaces

An interface is a collection of method declarations that allows unrelated objects to communicate with one another.

Interfaces are based on the distinction between a methods interface and its implementation. A methods interface includes all the information necessary to invoke that method, including the name of the method, all of its parameters, and its return type. A methods implementation includes not only the interface information, but also the executable statements that carry out the methods behavior. An interface definition contains only method interfaces, and any class that implements the interface is responsible for defining the method implementations. [8, pp. 90-105]

Chapter 3

Computer Networks

3.1 Introduction

The purpose of this chapter is to provide the necessary background to understand the concepts related to computer networks, focusing to explain the main concepts applied to the IEC 61850.

3.2 Transmission technologies

Types of transmission technology:

- Broadcast links.
- Point-to-point links.

Broadcast networks have a single communication channel that is shared by all the machines on the network. Short messages, called packets in certain contexts, sent by any machine are received by all the others. An address field within the packet specifies the intended recipient. Upon receiving a packet, a machine checks the address field. If the packet is intended for the receiving machine, that machine processes the packet; if the packet is intended for some other machine, it is just ignored. Some broadcast systems also support transmission to a subset of the machines, something known as multicasting [1].

In contrast, point-to-point networks, sometimes called unicasting, consist of many connections between individual pairs of machines. To go from the source to the destination, a packet on this type of network may have to first visit one or more intermediate machines. Often multiple routes, of different lengths, are possible, so finding good ones is important in point-to-point networks [1].

3.3 Local Area Networks

Local area networks, generally called LANs, are privately-owned networks within a single building or campus of up to a few kilometers in size. LANs are distinguished from other kinds of networks by three characteristics:

- their size,
- their transmission technology, and
- their topology.

LANs are restricted in size, which means that the worst-case transmission time is bounded and known in advance. Knowing this bound makes it possible to use certain kinds of designs that would not otherwise be possible. It also simplifies network management.

LANs may use a transmission technology consisting of a cable??????? to which all the machines are attached. Traditional LANs run at speeds of 10 Mbps to 100 Mbps, have low delay (microseconds or nanoseconds), and make very few errors. Newer LANs operate at up to 10 Gbps.

Various topologies are possible for broadcast LANs. Figure 3-1 shows two of them. In a bus (i.e., a linear cable) network, at any instant at most one machine is the master and is allowed to transmit. All other machines are required to refrain from sending. An arbitration mechanism is needed to resolve conflicts when two or more machines want to transmit simultaneously. The arbitration mechanism may be centralized or distributed. IEEE 802.3, popularly called Ethernet, for example,

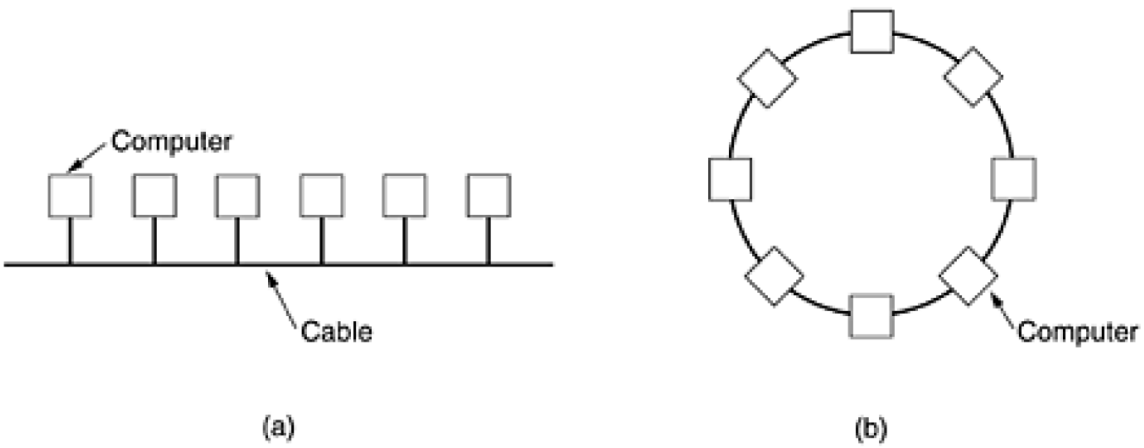

Figure 3-1: Two broadcast networks. (a) Bus. (b) Ring [1]

is a bus-based broadcast network with decentralized control, usually operating at 10 Mbps to 10 Gbps. Computers on an Ethernet can transmit whenever they want to; if two or more packets collide, each computer just waits a random time and tries again later.

3.4 Annotations

Appendix A

Tables

Table A.1: Armadillos

Armadillos	are
our	friends

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