Towards Interoperability Standards in Indian Power Sector

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Abstract

A sub-committee formed by Bureau of Indian Standards (BIS) namely, power system control and associated communications (LITD 10), is responsible for creation of standards for power system communications in India. In March 2010, six working groups were constituted, with members from government, utilities, industry, research and academic institutions, to expand the scope and overall participation in LITD10. The working groups are assigned respective topics - Interoperability, Security, Common Information Model, Phasor Measurement Units, Distribution Management System and Digital Architecture Framework. These Working Groups aim to address the technology gaps due to lack of interoperability among the technologies adopted by the utilities. The interoperability working group (WG1) aims to develop interoperability standards for power sector in India, covering the traditional value-chain, such as generation, transmission, distribution and newer elements of value-chain, such as availability based tariff, power exchange, renewable generation, risk management, home/office area networks, system operations. The levels of interoperability are broadly classified as communication technology, information technology and operation technology. An interoperability context setting framework suitable for addressing the unique requirements of India is developed, and used for advancing the standardization process. Harmonization among standards related to different aspects of the power system will also be addressed.

1. INTRODUCTION

Indian power sector is growing at an enormous pace. Various grid expansion and interconnection projects are ongoing to strengthen the existing transmission infrastructure to build a National Grid. The need for interconnecting power networks is in turn driving the need for interconnection of information networks. It is imperative that the power systems today utilize the capabilities that modern information and communication technologies provide. Interoperability among various communicating entities of the power system is crucial for achieving the benefits of a seamless integrated information network [1].

1.1. Initiatives

Under the Bureau of Indian Standards (BIS), the national standards are formulated based on the concept of consensus by the division councils [2]. The LITDC(Electronics & IT Division Council) is responsible for formulation of Indian Standards in Electronics & Information Technology field. Under this division council a sub-committee, namely, LITD 10 - Power system Control and associated Communications, is responsible for creation of standards for power system communications. In March 2010, six different working groups were constituted on Interoperability, Security, Common Information Model, Phasor Measurement Units, Distribution Management System, Digital Architecture Framework. The interoperability working group is one of the active groups with participating members from utilities, vendors, standards testing organizations, research and academic institutes.

1.2. Goals of Interoperability working group (WG1)

The goals of the WG1 are to develop interoperability standards for power sector in India as per following [3].

1. This would cover the traditional value-chain (generation, transmission and distribution)
2. It would also cover the newer elements of value-chain (trading, risk-management, renewable generation, ABT, home/office area networks, system operations (load dispatch centres))
3. It would cover IT (Information Technology), Communication Technology (CT) and Automation or Operational Technologies (AT/OT) and standards based integration between these components/layers
4. It would cover all the layers in the system starting from physical power system infrastructure, the communication network, the system software and application software
5. Harmonization among standards related to different aspects of the power system

The standards would be based on existing and/or emerging standards from organizations such as IEC, IEEE, NIST, CIGRE and others. It would select suitable and relevant standards for India and provide a guide (manual) on their adoption. IEEE defines interoperability as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”. This definition is about two decades old, long
before smart grid term was coined. A slightly recent definition from Open Knowledge Initiative [4] might be worth noting for the WG1 as it more focused on quantifying the benefits. “Interoperability – is the measure of ease of integration between two systems or software components to achieve a functional goal. A highly interoperable integration is one that can be easily achieved by the individual who requires the result.” Given the central role of interoperability in integration that is entrusted on WG1, it need to coordinate their efforts with all other working groups.

2. OVERVIEW OF INDIAN POWER SECTOR AND INTEROPERABILITY SCENARIO

In this section, the importance and immediate need of ground work for laying a solid interoperability foundation is highlighted. We provide an overview of Indian power sector, which at this juncture, is embarking on a path of investment and moving on a rapid growth trajectory.

2.1. Overview of generation sector

Ministry of Power (MoP) has launched an ambitious programme, “MISSION 2012: POWER FOR ALL” [5], an integrated strategy for the power sector development with multiple objectives, like sufficient energy production to achieve GDP growth rate of 8%, power reliability and quality, minimizing cost of energy, commercial viability of power industry. Indian power system has installed capacity of around 1,64,508 MW (as on 31.08.2010) and meets a peak demand of 114,737 MW[6]. Capacity addition of 78,700 MW is envisaged during the current five year plan. By the year 2012, the installed capacity is expected to be over 2,20,000 MW and the peak demand is expected to be around 1,57,000 MW. The generation sector is poised to witness unprecedented growth of four to five times in next two decades reaching about 800, 000 MW by end of 2030. Coal generation would still be a major contributor but its share in the overall portfolio is expected to reduce. Drivers, such as huge potential for untapped renewable energy, developments in distributed generation and micro grid technologies, and favorable regulatory environment, are attracting major investments from private sector.

2.2. Overview of transmission sector

Transmission sector is also growing fast with 242,400 circuit-kilometers (ckt-km) of high voltage AC and HVDC transmission network, including 765 KV transmission system of 3810 ckt-km[6]. The objective is to achieve a strong National Grid by 2012, which can facilitate on open access basis an exchange of power through out the length and breadth of the nation (Fig. 1). The transmission substations are currently at installed capacity of 325,000 MVA at 765, 400, 220KV voltage levels. All new substations being commissioned and built are IEC 61850 compliant.

2.3. Overview of distribution sector

Ministry of Power, Government of India has commissioned a report proposing a reform-roadmap on how to leverage digital technology to transform the power sector in India. The report was prepared by the Center for Study of Science, Technology and Policy (CSTEP) and Infosys [7]. The report discusses the challenges of the power sector in general, distribution sector in particular, the confluence of technology, policy and regulation; the interface between various stakeholders, the role of information technology as a catalyst and consumers as change agents. Some of the key takeaway points of the report are the following [7]:

- the investments in the telecommunication and IT infrastructure is not sufficient to keep up with the customer expectation and demand growth
- distribution sector has the highest return on investment for technology and has most pressing need for transformation
- the core challenges or burning issues for discoms are high power losses, aging infrastructure, poorly maintained assets, unreliable and overloaded systems, interoperability, demand side management and lack of skilled human resources.
- while the new infrastructure being installed is sophisticated and functional, the existing legacy systems can not be dispensed with, thereby needing a holistic approach to address the interoperability issues.
- open and flexible architectures can effect a transformation in the power sector and insulate it from evolution in technology making them future proof
- IT, communication, and automation must be planned and implemented in synergy to achieve optimal results
- setting up of a national institution is proposed to facilitate coordination among stakeholders across the industry, ensuring growth and synergy in development.
3. LEVELS OF INTEROPERABILITY

In reference [8] titled "Role of Interoperability in Indian power sector", some initial work is carried out on the interoperability scenario in and among control centres at state, regional and national levels in India. Building on this initial research, the working group on interoperability (WG1) is currently involved in gathering information on all aspects of interoperability in Indian scenario.

An important early step taken by the GridWise Architecture Council (GWAC) in its mission, was to develop a common understanding of interoperability, the various levels of interoperability, and issues of concern. To achieve this, a context-setting framework document [9] was developed to organize concepts and establish common terminology so that interoperability issues can be identified and debated, and actions prioritized and coordinated across the electric power community. A context setting framework provides a broad and neutral ground upon which the stakeholders can communicate.

Similar to the approach of GWAC, this paper serves the role of setting the context for interoperability for coordination within the working group, as well as other working groups. The interoperability framework should be developed not only to reflect the existing scenario of interoperability in Indian power sector but also to provide a vision for future development of a seamless integrated information network.

3.1. Levels of Interoperability

Interoperability occurs in various levels or layers. These layers span the details of the technology involved to link systems together, to the understanding of the information exchanged, to the business processes and organizational objectives that are represented in business, economic, and regulatory policy. Three broad levels were identified by the working group namely, Communication technology (CT), Information Technology (IT) and Operation Technology (OT). The scope of these levels are as described below.

3.1.1. Communication Technology (CT)

This level of interoperability address the the technical aspects of communication between the two systems. This covers defining the specifications of basic physical medium of connection, the network addressing and identification mechanism and the protocols for communication.

3.1.2. Information Technology (IT)

Even though the basic connectivity protocols are satisfied and a certain amount of information is communicated between two systems, the information may not be useful until it is semantically understood on a common basis. This can be achieved by conforming the information being communicated to a standard information model at a higher level of interoperability. As this level the semantics of the content that is communicated is standardised.

3.1.3. Operation Technology (OT)

At this level, the business context for communication between any two systems needs to be standardised. This defines the high level functions or services that are to be carried out to achieve certain organisational objectives. OT answers why information is to be exchanged, IT answers what information is to be exchanged, CT answers how information is to exchanged.

4. INFORMATION NETWORK PARTICIPANTS OF INDIAN POWER SECTOR

In this section, a model is presented which depicts the "logical" information network of Indian power sector. The logical information network is essentially a graph with nodes as information sources and sinks, which are interconnected with information branches. Information travels from source nodes to destination nodes over the information links across devices belonging to different systems, organizations, people, information representation formats and communication protocols. For example, national load despach center (NLDC) and regional load despatch center (RLDC) are two nodes in the network which share information over a communication link. The details of the underlying "physical" network are not covered in the model. The objective of mapping this information network is to identify all the participants and the types of information that is being exchanged between these participants. It is attempted to make this network model as comprehensive as possible covering all aspects of power system scheduling, operation, control and commercial settlement practices being followed in current Indian scenario.

Fig. 3. presents the nodes participating the information network. The nodes can be categorised as belonging to different kinds of utilities as described below.
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Figure 3: Participating Nodes in the Information Network

Figure 4: Scheduling Data Flow

Figure 5: Operational Data Flow

Figure 6: Commercial Data Flow
4.1. Generation utilities

The generation utilities in India range from regional level to local level. At regional level there are central owned ISGS plants. Ex. NTPC, NHPC and NPC plants. There are private gencos at regional level represented as ultra mega power plants (UMPPs) and independent power producers (IPPS). The gencos at the regional level inject their generation in the regional power pool through the central transmission utilities. Correspondingly at stage level there are state owned gencos, IPPS, MPPs and CPPs who inject their generation into the state power pools via the state transmission utilities. At local level all the sources of distributed generation, renewable energy sources are listed.

Every generator has an associated generator substation where the generated power is stepped up and evacuated to the grid. The real-time operational information on all these generators is measured and available at these generator substation via its remote terminal units (RTUs). This the substation RTUs form important source nodes in the information network. The RTUs report to the control control centers at the corresponding level as shown in Fig. 3.

4.2. Transmission Utilities

The transmission utilities in India are also hierarchical. Powergrid corporation of India limited (PGCIL) is the central transmission utility (CTU) at the regional and national level, while there are independent state transmission utilities (STUs) for each state. These CTUs and STUs form sources and sinks of information. The information on availability, maintenance and scheduling of all the transmission infrastructure is exchanged frequently between the transmission utility with its respective system operator. Similarly, the real time operational data on the entire transmission grid at all levels is obtained from substation RTUs (SS-RTUs). Additionally, phasor measurement units (PMUs) and phasor data concentrators (PDCs) are also being installed at various locations in India, which form a separate path of real-time phasor information reaching the control centers. The commercial settlements in India are carried out on the basis of data retrieved weekly from the special energy meters (SEMs) installed at the interfaces of the constituent power networks. All these information nodes which come under the transmission utilities are depicted in Fig. 3.

4.3. System Operators

Under the unified load despatch and communications (ULDC) scheme [10], the entire power system is operated by a hierarchy of control centers with well defined roles and responsibilities assigned to each level of system operation. Control centres form the major part of system operation, participating heavily in the information network.

4.4. Market Operators

The role of market operators is gradually increasing. Bilateral power traders and power exchanges are involved in carrying out the operations of the power markets. These markets participate in the information network as shown in Fig. 3. Salient Features of Indian power market can be summarised as - Energy Only, Physical Delivery, Voluntary participation, Double sided bidding, Uniform pricing, Day-ahead exchange, Hourly bids, Congestion management by market splitting, Multiple exchanges – Competition amongst exchanges.

4.5. Distributing Utilities

Following the restructuring of Indian state electricity boards many public as well as private distribution utilities have emerged in India. Distribution utilities (discoms) at the fore front of advancing the role of information technology in their operations are already reaping the benefits of lower losses, faster outage response, higher reliability and customer satisfaction. Thus discoms also need a well connected interoperable network to achieve remote operation capability and automated billing via deploying AMI and AMR.

5. INFORMATION EXCHANGES

Having identified the nodes in the information network, we move on to connect the nodes and form data flow diagrams. All the data exchanges have been broadly classified into four kinds based in the content being exchanged as defined in following sections.

5.1. Scheduling data flow

The data that is exchanged prior to the event of transfer of electrical energy comprising amount of power to be generated, transmitted and consumed by all the participants of the power network is defined as Scheduling data. The schedule is typically fixed ahead of the day of actual event, referred as (D-1) or before. In India the schedule is ultimately derived out of superposition of various contracts such as - long term open access (LTOA), short term open access (STOA), availability based tariff mechanism, power purchase agreements (PPAs), bilateral transactions, power exchange transactions etc. The nodal agency, at each of the levels (regional, state and local) is responsible for preparation of the schedule. The scheduling data flow network is shown in Fig. 4.

5.2. Operational data flow

The data that is exchanged simultaneously during the event of transfer of electrical energy comprising amount of power actually generated, transmitted and consumed by all the participants of the power network is defined as operational data. The operationally data is typically measured by
instruments in substations and transmitted by remote terminal unit (RTU) during the event, and thus is referred as "real-time" data. The direction of operational is bottom-up flowing to higher levels of hierarchy, while being collected, aggregated and summarised at each level. The operational data flow network is shown in Fig. 5.

5.3. Control data flow
The data that is exchanged as control commands from control centres is defined as control data. The network of control data flow is exactly same as that of operational data flow except that the direction of data flow is reversed. However, it is important to note that the same physical network is typically not used for exchange of control data. Following the decisions made in the control centres the control commands are despatched on phone communication by the operators with the agency who is responsible for carrying out the commands. Thus there is a human intervention in delivery of control operations of the system, which is a hurdle in implementation of closed loop automated control. At distribution system level there are some utilities equipped with capabilities of remote operation of the switches and circuit breakers.

5.4. Commercial data flow
The data that is exchanged after the event of transfer of electrical energy so as to calculate and disseminate the information on commercial settlements to all the participants of the power network is defined as commercial data. The commercial settlement is usually carried out after the day of actual event, referred as (D+1) or later. The commercial data flow network is shown in Fig. 6.

It is seen that at the organisation level, the roles and responsibilities are well defined among various kinds of Indian utilities [10]. This creates a hierarchical network of utilities involved in operating the power network by communicating over the information network. Every link in the communication is backed up with a specific business context as to why such a communication is needed. Following the restructuring of the power sector and under the active contributions from the regulatory agencies at all levels, the public and private utilities are evolving in a dynamic environment. Based on the data flow network in the above figures, it can be generalized that the the information flow is typically assuming a radial tree like structure.

6. STANDARDIZATION ACTIVITIES
Under the Bureau of Indian Standards, currently six different working groups are constituted on Interoperability, Security, Common Information Model, Phasor Measurement Units, Distribution Management System, Digital Architecture Framework, respectively. The different working groups were each assigned a convenor and a secretary and essentially the Working Groups were given free rein to create a Terms Of Reference (ToR) document and then work towards the completion of the objectives stated in the ToR. The WGs were also tasked to form their members from the list of participants in the initial steering meeting of the LITD10 subcommittee where the WGs were formed and also requested to induct other members as required to meet their requirements. The WG1 formed a ToR [3] with objectives as described in section 1.2 and inducted members from Utilities (3 organizations), major IT companies(4 organizations), Government Research Institutions (1), original equipment manufacturers in the power sector (5 organizations) and Academics Institutions (1). The WG1 scheduled and conducted several meetings which resulted in the formation of sub-groups for IT,OT and CT and the creation of the context-mapping document. The WG1 is currently working on a comprehensive questionnaire that covers the important aspects of IT, OT and CT use within Utilities aimed at extracting the as-is state of the workings of these technologies. The WG aims to deliberate on the findings from the questionnaire and move on to forming recommendations which will ultimately result in the creation of the Interoperability Standards

7. CONCLUSION
The current scenario of growth in Indian power sector is briefly outlined, highlighting the need for Interoperability standardization at various levels through out the sector. This paper identifies the importance of establishing a solid interoperability foundation and outlines a contextual framework among all the participating organizations to coordinate, communicate, collaborate and contribute in addressing the interoperability issues in Indian power sector. As a new wave of investments are already underway in expansion of the sector at all levels, it is imperative that the interoperability standards are established and adhered for deriving long term returns from these investments.

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Biographies

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