Real-Time Commercial Supervision at Petrobras

Anthony Collins, Emerson (formerly Energy Solutions Int'l.)
Odilia Dauzacker, Transportadora Brasileira Gasoduto Bolívia-Brasil S.A.
William Fernandez, Emerson
Marcos Moraes, Petrobras Gas Natural

Abstract

Real-time models and associated applications have been widely used to support the safe and efficient operation of pipelines from within the confines of the pipeline operations environment. Commercial systems have also been independently implemented to manage the business relationships between gas suppliers, shippers, transporters, and end users; however, the direct interchange of information between models and commercial business systems has typically been limited. As part of a comprehensive upgrade of their gas shipping system, Petrobras has implemented a real-time model on several of their pipelines, integrating SCADA and model data with the new shipper system. The shipper system provides Petrobras with the capability to schedule, consolidate, allocate, and provide detailed energy and volume information for invoice generation. Real-time model and SCADA data are used by the shipper system to provide real-time supervision of the shipper contracts by monitoring and reporting contractual gas quality, volume, and operational pressures, directly against commercial contract parameters, in real time. Further, a nomination forecasting application is used to forecast supply and demand, identifying future volume and energy penalty conditions. Through web access, each client also has the capability to monitor real time flow profiles against their nomination and nomination forecast profiles, allowing the client to be proactive in avoiding penalties. In this paper, an overview of the shipper system functionality and its integration and use of real time data will be provided. The challenges, experiences, benefits, and future enhancement considerations will also be discussed.

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Introduction

The Brazilian gas market is regulated by ANP (Petroleum National Agency) from its production to the delivery to distributors. Distribution to final consumer is a monopoly of each Brazilian State government which is executed through concession to private companies.

A Federal Law from 1997 defines six different roles for the gas market and the activities and combinations allowed among them. These roles are: producer, processor, importer, shipper, transporter and distributor. The diagram in Figure 1 below shows the relationship between these roles with respect to the physical flow of gas and commercial relationships. It should be noted that the processor is not shown in this diagram. In reality the processor sits between the transporter and the producer. The retailer in this diagram is known as the shipper throughout this paper.

Prior to 1997, Petrobras, a corporation formed by the Brazilian government in 1953, was the only player in the Brazilian gas market, except for the distributor role that was already given to the States by the constitution of 1988. After the 1997 Federal Law, Petrobras created Transpetro to act as transporter, operating all existing pipelines in Brazil. At the same time, a new private company was created to build the Bolivia-Brazil pipeline, with 51% participation of Petrobras.

In the year 2000, a natural gas business unit was created in Petrobras to play the shipper role. As the largest oil & gas company in Brazil, Petrobras is the main shipper for both gas transportation companies. This paper describes the development of an information solution to support Petrobras gas shipping business. In order to understand the magnitude of this project, some basic information on the Brazilian pipeline network is now presented.

Transpetro's pipelines are grouped into three main networks as shown in Figure 2 and described below:

- **Northeast Network** – This network is composed mainly of five pipelines: First pipeline called GASFOR with one receipt point, four delivery points and a length of 238 Miles (383km), Second and third pipelines called NORDESTÃO/GASALP with two receipt points, eleven delivery points and a length of 390 Miles (628 km). Fourth pipeline called GASEB with one receipt point and eight delivery points, and the last Sub-Network, which includes four pipelines, a length of 93 Miles (150 km) and ten delivery points. The Northeast Network runs through seven states in Brazil (Bahia, Sergipe, Alagoas, Pernanbuco, Paraíba, Rio Grande do Norte e Ceará) and moves approximately 300 Million ft³/day (8.5 Million m³/day).
- **Southeast Network** – This network includes six pipelines, GASDUC I / GASDUC II with one receipt point each and three delivery points. GASVOL / GASPAL with three receipt points (one of these receipts is the interconnection with GASBOL) and fourteen delivery points, GASBEL with one receipt point and five delivery points and GASAN with two receipt point and three delivery points. The Southeast Network runs along three states (Rio de Janeiro, São Paulo e Minas Gerais) and moves 706 Million ft³/day (20 Million m³/day).
- **East Network** - This is a small network that moves 35 Million ft³/day (1 Million m³/day). It is located in Espírito Santo state.

The Bolivia-Brazil gas pipeline, known as GASBOL, runs from Rio Grande in Bolivia to Canoas in Brazil with a total length of approximately 1,926 Miles (3100 Km) of which 1,611 Miles (2,593 km) run under Brazilian soil. It is operated by Transportadora Brasileira Gasoduto (TBG). This pipeline will transport Bolivian natural gas to Brazilian consumers, with a total capacity of 1,060 Million ft³/day (30 Million m³/day). GASBOL runs through five states: Mato Grosso do Sul, São Paulo, Paraná, Santa Catarina e Rio Grande do Sul.

There are currently 18 gas distributors in Brazil and Petrobras has some participation in most of them. Gas shipping for Petrobras means purchasing, selling, and transporting domestic and imported natural gas. Domestic gas is purchased from within Petrobras, and imported gas is purchased from YPFB, Bolivia. Gas is transported through transportation agreements with Transpetro and TBG.

Previously, these activities were performed by Petrobras Shippers using a complex set of spreadsheets, faxes, and phone calls, along with a Petrobras developed client/server data entry and a net volume and property calculation system known as I-Gas.

The evolution of the Brazilian gas market motivated Petrobras to make the decision to go beyond the typical processes of nomination/scheduling, daily balance and invoicing in order to be able to identify and take advantage of business opportunities and increase profitability. Gas scheduling should be more than just managing balances between transporter capacity, supplier availability and consumer demand, it should target matching optimization based on contractual rules, to earn more or loose less, depending on the context. Moreover, a new process emerged as a significant distinction to Petrobras gas shipping business: the commercial supervision process.

Petrobras realized that with their existing tools it was not feasible to implement the process evolution and this was the genesis of the project. A new system was required to provide Petrobras with the capability to manage the scheduling, supervision, and consolidation activities, replacing many of the manual and time-consuming processes with a more accurate and efficient system that also provides the opportunity to minimize contractual penalties, while improving the service it provides its customers.

Process Description

The gas shipper in Petrobras performs the activities of Scheduling, Supervision, Monitoring of Measurement and Gas Quality, and Consolidation for Invoicing, as described below and illustrated in Figure 3.

Scheduling

This process occurs daily before the start of the gas day and is the first activity of the shipping process as outlined in Figure 4 and Figure 5. It is initiated by the end users with the submission of nominations. Available associated gas and processing capacity are also received from suppliers and processors. This information is processed along with available capacity provided by each transporter for each pipeline and with the contractual conditions to determine the quantities to be nominated by the Shipper to their suppliers, to the transporter and the confirmations to the clients. The Scheduling activity is complete when all nominations have been confirmed and accepted by all parties with minimal contractual violations or penalties, if any.

Commercial Supervision

Commercial supervision starts at the beginning of the gas day and is described as the near real time monitoring of the conditions that affect the commercial terms of the contracts between Petrobras and their clients, transporters, and suppliers. Each contract for buying, selling, or transporting gas has certain requirements, such as minimum delivery pressure, and gas quality for example. Commercial supervision allows Petrobras and the client to monitor the conditions against contractual requirements, allowing them to respond quickly to any observed or projected violations of those contracts.

Commercial supervision does not substitute operational supervision, in any aspect. Even though real-time operational data is fundamental to the process, it is only one part of the necessary information. Commercial supervision must consider, and have access to, all information concerning contractual limits, penalties and clients' profiles and consumption patterns.

Keeping track of what is actually happening during the day enables the shipper to identify business opportunities which may not have been previously identifiable. The interaction between the business world and the operational world is the basis for this new process.

Penalizing a client who did not pull the scheduled amount of gas may not be the best business decision. Being able to foresee that the client is not going to accomplish the schedule may bring, on the other hand, an interesting business opportunity. That is what commercial supervision is all about. In this case, many possibilities are to be considered, including reselling the gas to another client while freeing the first one from the penalty and gaining his fidelity. The chance to do intra-day re-nominations, established in most contracts, makes this feasible.

Getting to know that some amount of gas in the pipeline is out of the contractual specification to be delivered to some client allows the shipper to negotiate a lower rate or to redirect the gas to another client to whom that gas is in compliance with the contractual specification. Additionally, providing real time information on contract performance to the shipper provides the shipper with the opportunity to make business decisions that he would otherwise not be able to make.

Measurement

Measuring is not an activity under the responsibility of the shipper. However, the shipper relies on this information to charge the clients and to pay for the purchased, transported and processed gas. The measurement process checks the quality of the measurement data that is received from the producers, transporters, clients or processors, with the goal of early identification of eventual measurement failures and the application of the contractual rules whenever a failure is detected. This process is completed when the official gas volumes are assumed for consolidation.

Quality

Because of legal and contractual conditions Petrobras must monitor the quality of the gas that is purchased, transported and delivered. As with the measurement data, quality data can be received from producers, transporters, clients or processors.

Quality data refers to the gas components (result of gas analysis) and gas properties (calculated from gas components). The calculation of the gas properties is based on the ISO6979 or ASTM3588 standards. This process validates gas component data, and calculates gas properties, with the goal of early identification of eventual gas quality problems, as well as, correction of volumes to standard conditions.

Consolidation

Consolidation is the final activity of the gas shipping process. It is responsible for matching the planned versus actual gas movements and calculating volumes to be charged or paid for, as well as any applicable penalties according to the purchase, transport, processing and sales contracts. Figure 6 contains an overview of the gas consolidation process.

Shipper System Design

As shown in Figure 7, the system consists of three main components: A hydraulic model, a load forecaster and a business database application. All the modules interact with each other to provide an integrated solution.

Contractual information is the basis of this system. The business application maintains this information and uses it for most of its operations. The business application also manages scheduling, quality, measurement and consolidation.

The hydraulic model gets its input data from the transporter SCADA systems and provides the shipper operational information of the pipeline networks. This information together with contractual data allows the shipper to supervise the commercial operation of the pipeline, quickly identifying conditions that could generate penalties.

The load forecaster provides predictions of load profiles for supply and delivery points along the pipeline. The current load profile is projected to the end of the gas day using one of three methods and compared against the predicted profile. Information from the comparison is used by the shipper to predict possible undesirable conditions and also provides information to the clients that help them plan their consumption.

The interaction and exchange of information between the different modules is crucial for the success of the system. The contractual data is obtained by the hydraulic model from the business application and used to detect violations of contractual conditions in real time. The hydraulic model is capable of identifying violations in pressure; flow and gas quality, generating alarms, sending email notifications and calculating accumulated volumes.

The business application relies on the hydraulic model to determine and provide certain data. Operational volumes from the model are used to identify suspicious data in scheduled and official volumes. Accumulated volumes that were out of specification or in violation of contractual conditions are obtained from the model and used in the business applications during consolidation.

Business Application

Contracts

The contract module is used as a single source of contractual conditions for all the different components of the system, as well as providing the shipper with the ability to configure events and notifications that are generated according to contractual conditions. Different types of events are available: recurrent, on contractual value changes, on contractual date, and on specific date.

A contract definition is built out of configurable standard items and events. All contract items must be one instance of a standard item, with a value for the particular contract. Events work in a similar fashion. When an event is configured for a particular contract item, a standard task must be specified for the event.

Scheduling

The business application handles the scheduling by network. A network is composed of a set of pipelines, each associated with a unique sequence number. Each pipeline can be associated with delivery points, receipt points, interconnected points, and processing units. One of the points in the pipeline must be configured as a "calculated point". The calculated point is used during the matching of volumes as the unknown variable in the balance equation. Then, each of the pipelines is resolved according to the sequence of the pipeline in the network. The volume matching algorithm also considers the priority of each delivery point in a pipeline, physical capacities, and contractual conditions specified in purchase, transport, processing and sales contracts.

Quality and Measurement

In order to detect suspicious quality and measurement data, the system provides a mechanism to create profiles of typical behavior. When data is received outside of the profile limits the value is flagged and a configurable list of users is notified. All the corrections in the system are done using industry standards AGA-8, ASTM3588 and ISO6979.

The system also provides contractual configurable actions to be performed in the event of measurement failure.

Consolidation

The system provides an extremely flexible way to configure contractual penalties for all the parties involved in the gas transportation process. Petrobras has provided a set of standard terms that are used to calculate penalties. The user can create penalties and use the standard terms in a formula editor. At consolidation time, penalties are calculated with the defined formula, and the terms for a particular contract are evaluated.

Shipper System Implementation

There are a number of challenges to consider when implementing a system that has multiple input data sources, processes, and groups of users, each with different access and information requirements.

Given that a goal of the system is to improve accuracy and efficiency of the shipping process for Petrobras, then all users that form part of the shipping process are required to accept and use the system to perform their particular role in the shipping process. Clients that previously submitted nominations and received nomination confirmations by spreadsheet now need to perform the same function using a web browser. In some cases the end user requires that nomination information continues to be maintained in spreadsheet form for their own internal consumption. In this case, the user is provided with the capability on the web page to upload and download nomination data from the spreadsheets.

Should a supplier, processor, transporter, or end user, not have access to the system at any time, then the shipper has the capability to enter the necessary information into the system on their behalf.

Transition from the existing system to the new system is currently being performed in four phases:

- Phase one dealt with implementing the Contract Manager and configuring contractual terms. Phase one also included integration of the supervision process with contract data as well implementation of scheduling, gas quality, and measurement applications.
- Phase two focused on implementing the consolidation process as well as adding additional functionality to the processes implemented in phase one.
- The project is currently entering phase three where the complete process from scheduling to consolidation and invoice generation is being performed in parallel with existing operations. This phase of the implementation is primarily concerned at verifying the performance and accuracy of the system with respect to sales contracts only.
- Phase four will be a repeat of phase three, but will include validation of purchase and transportation contracts as well as any adjustments and system changes observed during previous phases.

Operational Observations

Operational observations can be categorized from the perspectives of the different users of the system. The main user seeking the most benefit of the system will be the Petrobras shipper. Other users include the end gas customer, gas supplier, gas transporter, and gas processor. Because system implementation is currently entering phase three, not all users have had sufficient exposure to the system to establish extensive operational observations. However, the following is a summary of operational expectations for each user:

Gas Customer, Supplier, and Transporter

- Ease of nomination submission, and faster confirmation
- Better penalty management based on real time information instead of after the event
- Email nomination notification and confirmation

Gas Shipper

- Centralized nomination and scheduling
- Real-time view of operational data against contractual requirements
- Contract event management
- Timely and more accurate penalty calculations
- Suspicious data identification
- Email alarm and event notification

Future Enhancement Considerations

During the implementation of the system several enhancements have been identified that could extend the usability, effectiveness, and efficiency of the system. The following is a summary of enhancements that are currently being considered.

- Include contract phases for transportation and sales contracts
- Additional pipelines
- Implement weather forecast data in load forecaster
- Upgrade user interface
- Integration with calibration system
- Integration with maintenance systems
- Interface to integrate the transfer of nominations between Petrobras and transportation companies

Conclusion

The complex nature of the Brazilian shipping business, combined with the existing process of using spreadsheets, faxes, email, and phone calls to manage Petrobras' shipping process, provided an identifiable opportunity for improving efficiency. Initial improvements could have been achieved by implementing a stand-alone scheduling and consolidation system. However, given the availability and accessibility of real time operational data, the shipper system has been extended to provide real time monitoring of operational conditions that may affect compliance with commercial agreements and ANP regulations.

Making certain real time operational data available within a shipping system has also provided the shipper with the opportunity to capitalize on business opportunities that may not have been identified in the past.

Figures
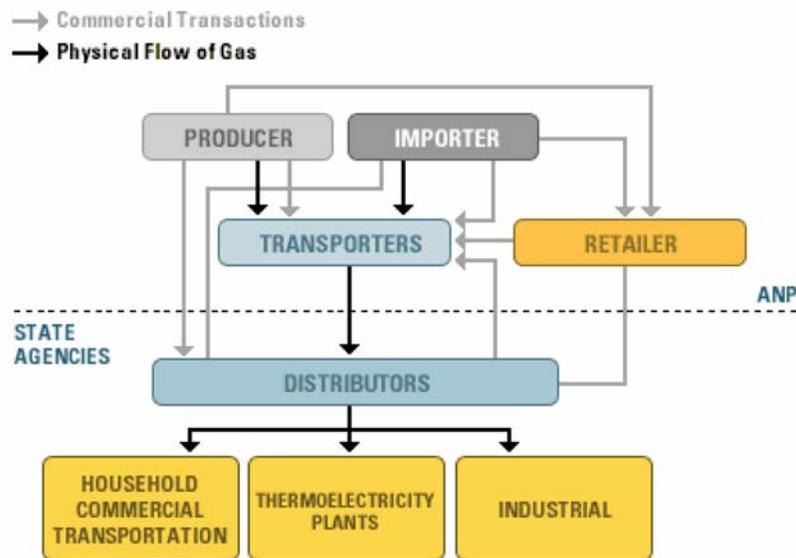
Figure 1. Gas Trading Structure
Source: Petrobras; http://www.gasenergia.com.br/portal/ing/areanegocios/gasestrutura.jsp

Figure 2. Gas Pipelines in Brazil
Source: Petrobras; http://www.gasenergia.com.br/portal/ing/areanegocios/gastransporte.jsp
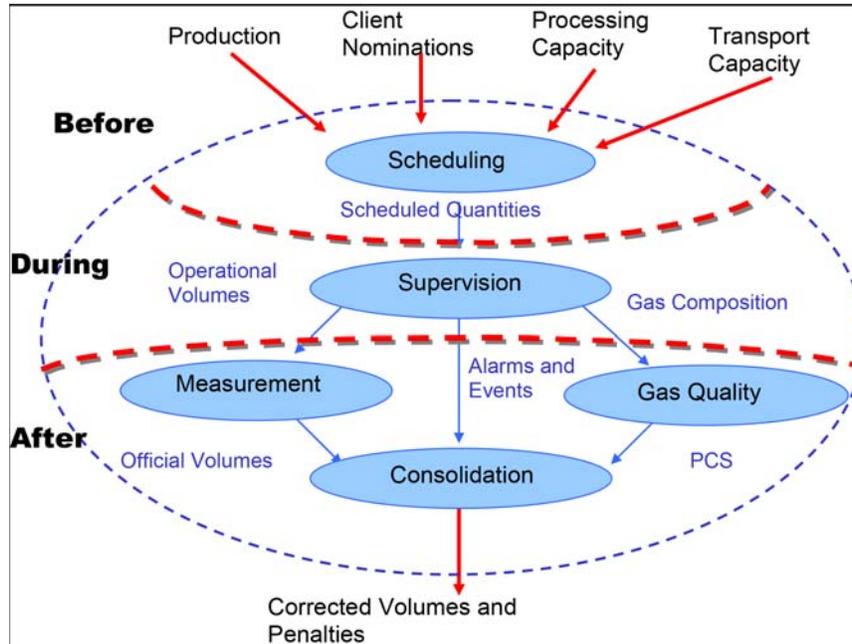
Figure 3. Petrobras Shipping Process Overview
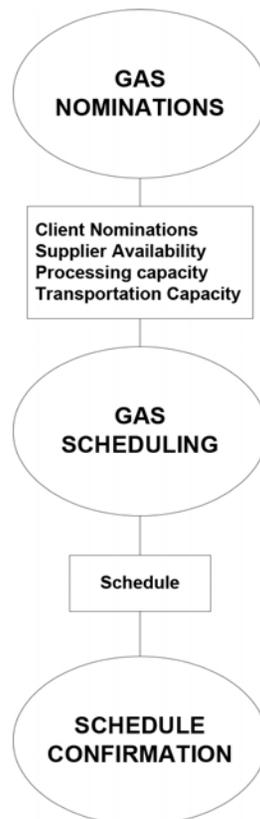
Figure 4. Scheduling Overview

Producer

Receive Gas
Availabitity Values

Define Actual Gas
Availability

Receive Gas Availability for a
Purchasing Contract

Recieve Processing Capacity
Availability Ranges

Processor

Receive Clients'
Nomination

Scheduling

Scheduler

Send Transport
Request

Client

Transporter

Receive Transporters'
Confirmation

Send Gas Request to
Producers

Receive Producers'
Confirmation

Send Clients'
Confirmation

View Confirmation - Client

Browse Scheduling
Confirmation and Requests

Figure 5. Scheduling Process
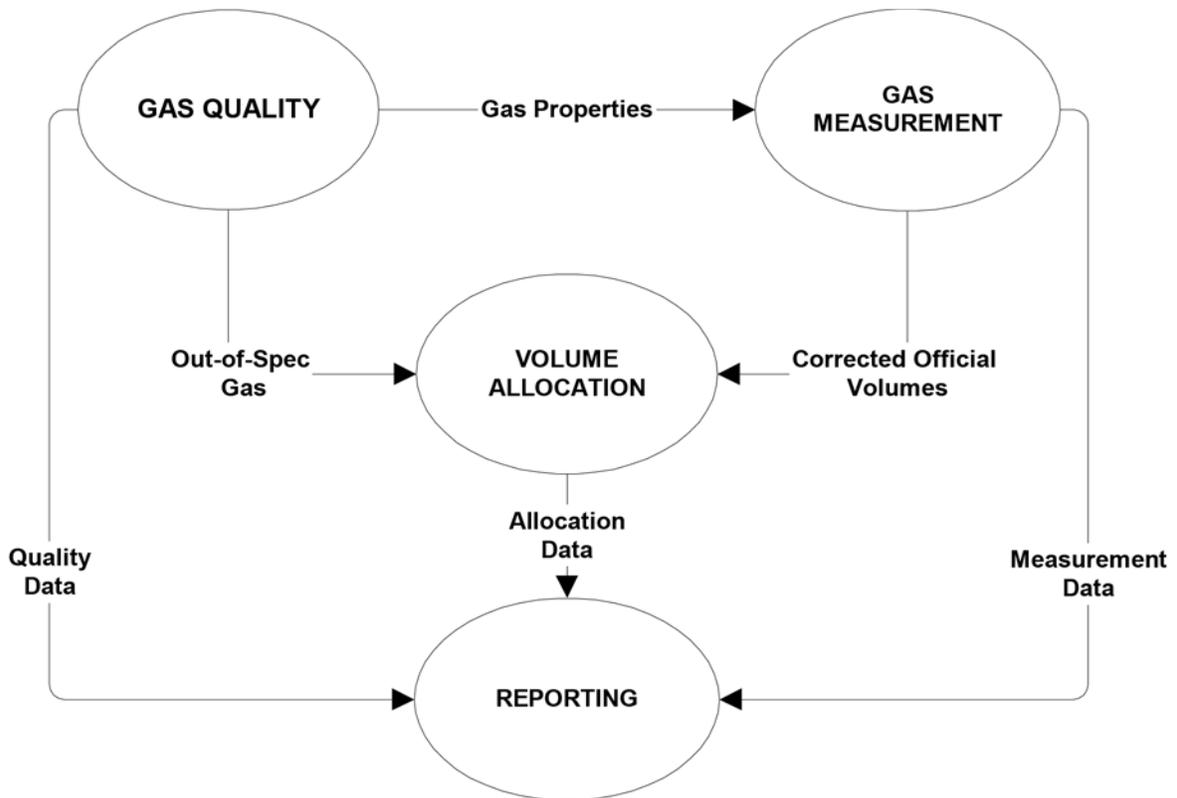
Figure 6. Gas Consolidation Process
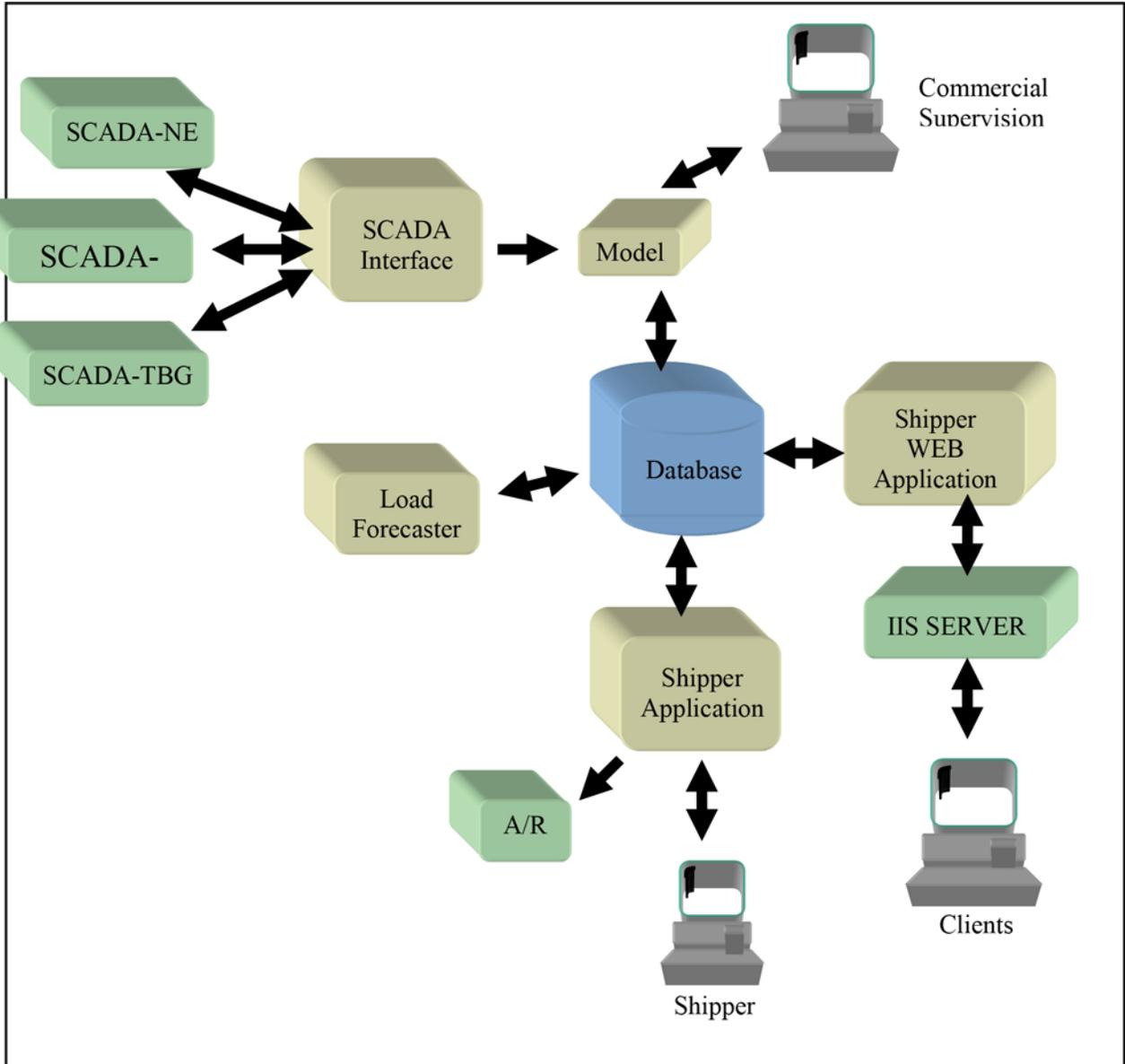
Figure 7. System Overview Diagram

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Global Headquarters
North America and Latin America
Emerson Process Management
Remote Automation Solutions
6005 Rogerdale Road
Houston, TX, USA 77072
T +1 281 879 2699
F +1 281 988 4445

www.EmersonProcess.com/Remote

Europe
Emerson Process Management
Remote Automation Solutions
Unit 8, Waterfront Business Park
Dudley Road, Brierley Hill
Dudley, UK DY5 1LX
T +44 1384 487200
F +44 1384 487258

Middle East and Africa
Emerson Process Management
Remote Automation Solutions
Emerson FZE
PO Box 17033
Jebel Ali Free Zone - South 2
Dubai, UAE
T +971 4 8118100
F +1 281 988 4445

Asia Pacific
Emerson Process Management
Asia Pacific Private Limited
Remote Automation Solutions
1 Pandan Crescent
Singapore 128461
T +65 6777 8211
F +65 6777 0947

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