SIMONE Capacity Tools and Gas Transport Commercial Management System Integration

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Summary:

Calculation of Available Capacity is very important task for TSOs due to internal and external reasons:

- Reliable information on available capacity represents the basis for internal short- and long-term planning and optimisation of system operation and development,
- Publicly accessible information on available capacity is one of cornerstones of any deregulated gas market.

Generally, within the entire gas industry, the dynamic gas network simulation is used as a basis for calculation of available capacity.

The complex structure of the gas transport system, not only from the physical, but also from the commercial point of view makes this task very difficult. The main source of difficulties lies in the complexity generation of the scenario. On the other hand, calculation process has to be transparent because of the public interest.

The paper will present the method of available capacity calculation applied to Plinacro Commercial Gas Management System.

Available capacity calculation in the case of Plinacro system is divided into 2 phases:

- Preparation of basic data for capacity calculation (boundary flows and selection of network constraints and controls),
- Iterative simulation algorithm performed on the mathematical model of gas transport system.

Basic scenario data are generated from a set of available commercial data. These data, organized according to the commercial gas transport system model, are expanded into a form in which they can be mapped onto SIMONE gas network model components.

Initial commercial data are stored in the commercial system database (transport contracts, access contracts, and commercial transport model). After a boundary flows scenario is generated, it is stored, together with other scenario data in the form of an XML file that is passed to SIMONE capacity tool. When the capacity is calculated, SIMONE capacity tool returns results back to the commercial application that makes the reverse operation, i.e. maximum boundary flows through physical network nodes are converted into maximum flows by commercial entry and exit points.

Within SIMONE capacity tool several network models are developed to enable capacity calculation for different time periods, and to accommodate to the planned future network expansion. In the same way, common constraint and control scenarios are developed, as well as several variants of the control scenario. Control scenario variants are used to enable covering of different control strategies used in different seasons.

All these elements are used to create certain simulation environment – network model, as well as a simulation execution scenario. The calculation algorithm is iterative, based on a series of scenarios. The simulation process starts with execution of the basic scenario (contracted capacities). In the subsequent scenario boundary flows are gradually increased. Several different strategies are developed for increasing of boundary flows in the calculation scenario. A commercial user can choose one out of these strategies and send it in an appropriate order to SIMONE capacity tool, together within scenario data: The repeating process is stopped when certain network constraints are violated. Reached boundary flows represent gas transport system maximum boundary flows for selected assumptions and the selected simulation execution control.

It is the responsibility of every commercial user to control execution of the simulation in the way that will give the most representative available capacity figures. This paper presents a designed solution which will give a tool for an efficient execution of that task to every user.

1. Introduction

According to national and European regulations, TSO Plinacro is obliged to calculate and publish information on capacity situation for all relevant points of the gas transport system on a regular basis. This information has to be published at least once a month for the minimum of 18 months in advance on the rolling horizon principle. The published information has to contain technical, booked and available capacity per each relevant point as a minimum. Different entry and exit flow patterns have to be taken into account for the daily time period.

This information is useful in the first line to network users, but it can be also used by TSO in gas transport service contracting business process. Prior to granting of any booking request to the network user, the check-up is to be made comparing the user's capacity booking request against the published capacity figures, and in particular regarding entry and exit points. When the requested capacity change is small, the stated check-up will be sufficient. Nevertheless, there are also situations when TSO has to perform additional capacity calculations concerning that particular booking request to be able to grant or refuse the booking requirement to the particular network user.

Within any daily operation, nominations are usually allowed up to the booked entry / exit flows, and normally no additional check-ups of nominated entry / exit flows are necessary. However, there are a number of special cases (planned or unforeseen maintenance, congestion, etc.) in which additional capacity check-ups will be necessary.

All these capacity calculations represent a part of commercial gas transport management processes in which they serve as a sophisticated tool for decision making. Calculations are performed by means of a static or a dynamic simulation on the gas network model. SIMONE software has been selected to perform these tasks. For calculation of available capacity or checking-up of users booking requests, standalone SIMONE instance can be used. On the other hand, SIMONE real-time instance has to be used for any nomination process. To facilitate application of the stated SIMONE tools, they have to be integrated into the Commercial gas transport management system.

2. Commercial Gas Transport Management System

The Commercial Gas Transport Management System supports fulfilment and control of the function of TSO commercial gas transport management. Within that business function it gives support for following business sub functions:

- Gas transport capacity booking (contracting)
- Nomination
- Metering
- Allocation
- Balancing
- Invoicing
- Secondary market trading
- Gas options trading.
- Common data maintenance.

Figure 1 displays the model of TSO Plinacro commercial gas transport management business function. Each of business sub functions contains several business processes defining procedures of business activities, business rules and user roles. The Commercial Gas Transport Management System enables automated exchange of business information among various participants in business processes, and recording and maintaining of corresponding business transactions.

The IT system that supports commercial business activities is designed as a transactional system with the central database in which all transactions are recorded and maintained. Access to the system is realized by the common company portal. The system is based on the application of web services and SOA architecture.

For some business processes sophisticated tools are necessary to support the decision making process. One of the most recognised applications of that kind is SIMONE capacity tool which is used in connection with capacity calculation or capacity validation. SIMONE applications are installed as standalone applications that are integrated with Commercial Gas Transport Management System. The integration is done by enabling communication among different applications using web services.

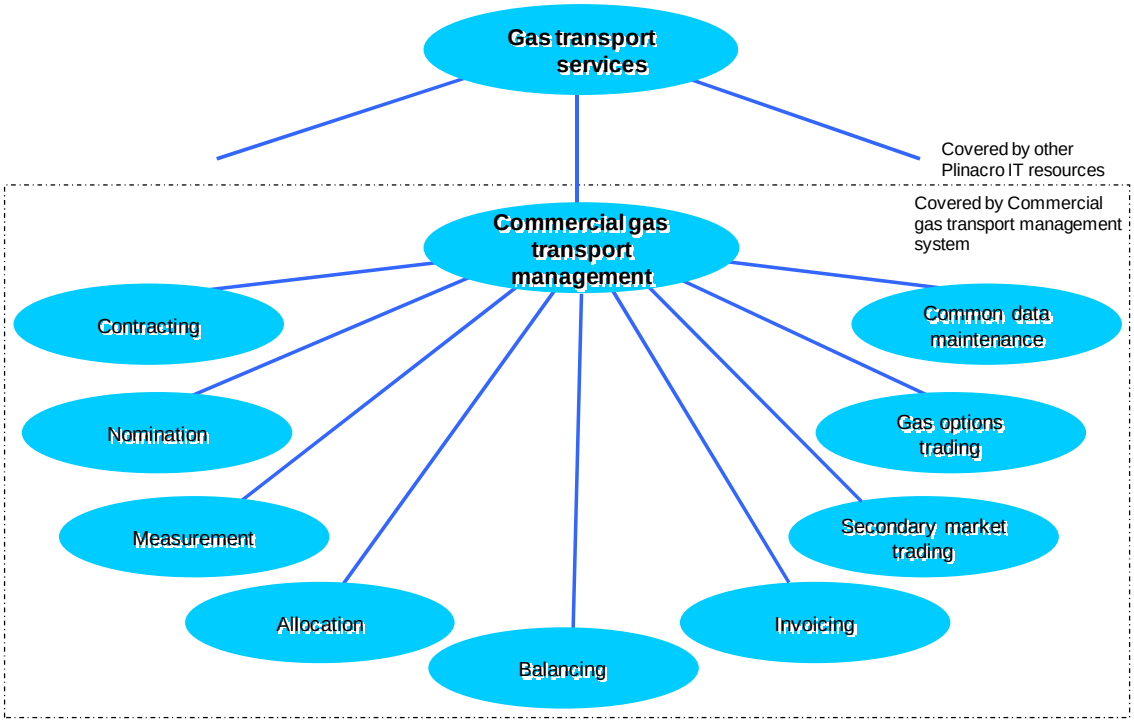


Figure 1: TSO Plinacro - Commercial gas transport management business function

The Commercial Gas Transport Management System has the central position in the company IT structure. It collects commercial data from market participants and transforms them into a form suitable for the process control on the daily basis. On the other hand, summary data is communicated to the company ERP periodically to enable generation of invoices for gas transport services performed during that period.

At the user level the commercial gas transport management system enables access to commercial data to numerous external and internal users. Different commercial business reports are regularly generated and put at disposal to the company management, as well as to many external gas market players.

3. Commercial gas transport model

The communication between different levels of business hierarchy (process, commercial, management) is based on a smooth data flow between applications supporting business processes at the individual hierarchy level. Together with communication, these data have to be transformed into a form suitable for the destination application.

The logical framework for the execution of automated data transformation is the commercial gas transport model. This model is positioned within the Commercial Gas Transport Management System and represents a common basis for execution of all business processes. It is a data structure stored in a special database module (a set of tables), and consists of several types of entities:

- Physical gas network objects (off-take and in-take-stations, meter lines, physical reception and delivery points)
- Commercial gas network objects (entry and exit points)
- Physical external systems (distribution networks, industrial consumer facilities, production facilities, cross-border stations, underground gas storage facilities)

- Business partners (shippers, wholesalers, buyers, producers, etc.)
- etc.

The model also contains the structure and relations among different model entities.

It also comprises the built-in time dimension (validity range – from the start date to the expiry date) and the status (in construction, active, out of operation) information.

The commercial gas transport model enables:

- Relating technology data (e.g. meter readings) with commercial data (capacity bookings, nominations, etc.).
- Relating commercial data (e.g. nominations) with technology data (transport plans).
- Constructing of simulation scenarios on the basis of commercial data
- Calculation of commercial capacity data on the basis of maximized scenarios which are result of simulation.
- Relating commercial and business data (invoices, business reports, etc.)

As a result, internal users and gas market participants deal with data in the format and having contents adjusted to their individual needs.

Figure 2 shows the gas transport system from the commercial point of view. Commercial users consider the system as a set of entry and exit points which are connected to the common network through virtual nodes. At the commercial level, gas is received from shippers at entry points, and delivered to buyers at exit points. All resulting commercial transactions (capacity booking, nomination, allocation, balancing, etc.) are structured according to entry and exit points.

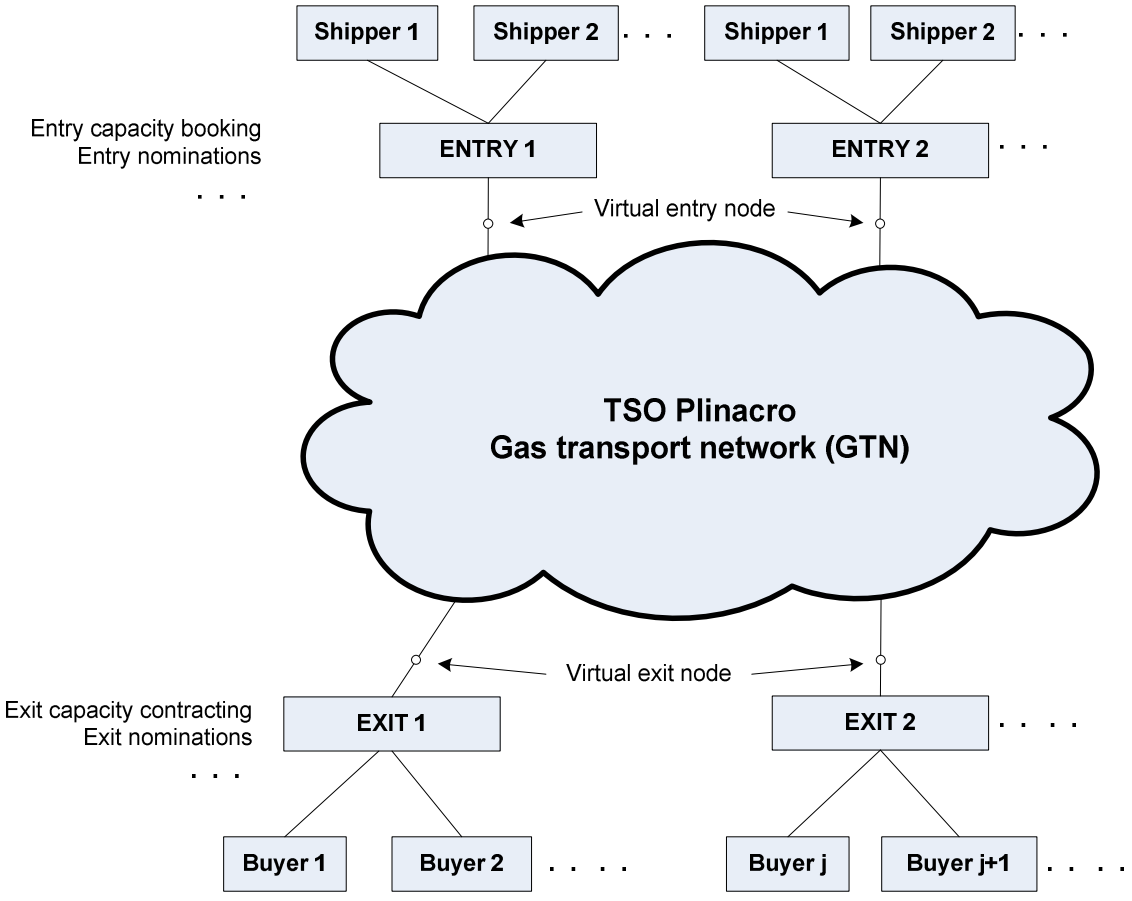


Figure 2: Gas transport system from the commercial point of view

Figure 3 represents the gas transport system from the technological (or process) point of view that consists of gas transport pipelines and different process plants. Process plants presented on the figure enable connection to external process plants: production facilities, trans-border stations, gas storage facilities, off-take stations, etc. that serve to receive gas from and / or deliver gas to external participants. Each process plant may form one or more physical receipt and/or delivery points. E.g. off-take stations supply gas to one or more buyers, while buyers can be supplied from 1 or more off-take stations as indicated on the figure.

Physical receipt and delivery points are places where gas flow, quantity and other quality indicators are being measured. One or more metering lines are used for each individual receipt or delivery point. Physical receipt and delivery points are connected to the pipeline network at physical nodes that represent nodes in SIMONE gas network model as well.

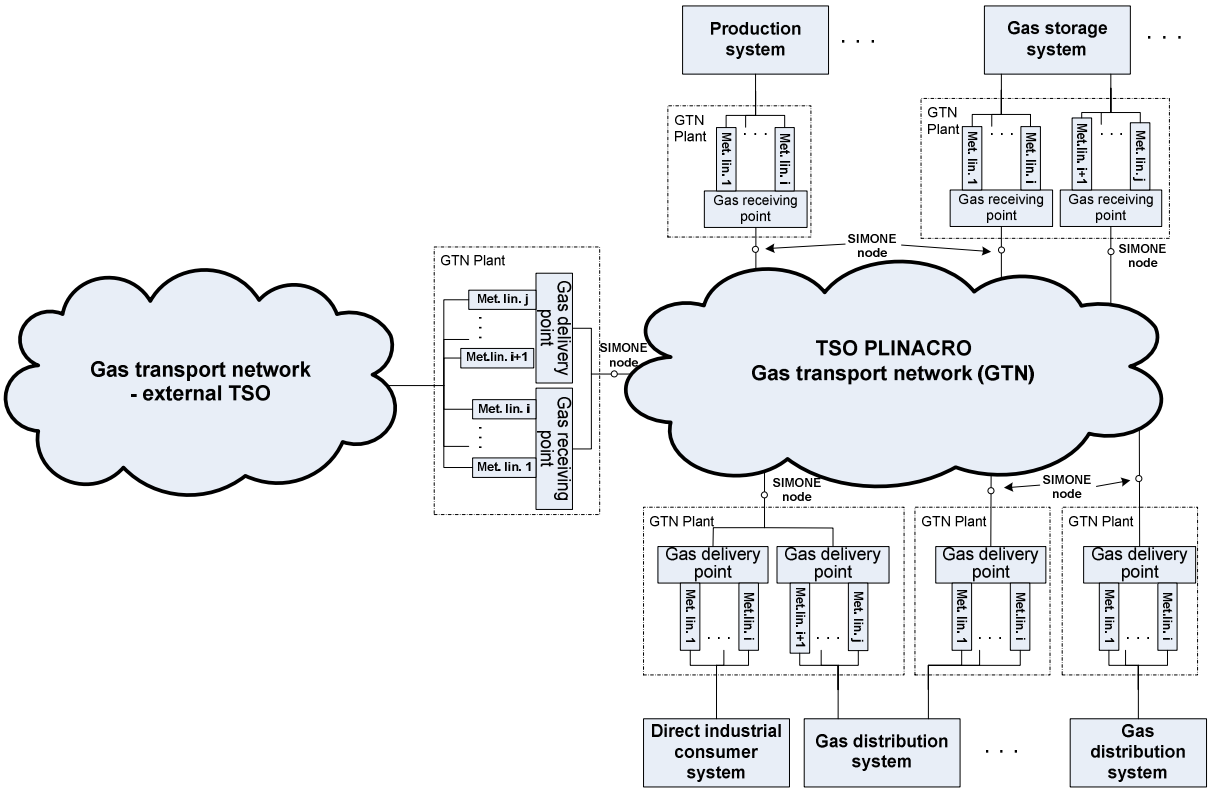


Figure 3: Gas transport system from the technological point of view

At the commercial level shippers send their nominations by entry and exit points on the daily basis. When those nominations are confirmed, a transport plan is generated and delivered to gas network operators. The transport plan is structured by physical receipt and delivery points. In the opposite direction, received and delivered gas quantities are daily measured by TeleMetering system on individual metering lines. Telemetered data are stored in TeleMetering database. Metered data that are structured by individual meter lines serve as a basis for allocation of gas quantities to individual shippers with the help of entry and exit points.

If SIMONE is used for capacity calculation, simulation will be executed on the gas network model on which SIMONE nodes coincide with physical gas network nodes. On the other hand, scenarios for simulation have to be constructed on the basis of commercial data that are structured according to virtual commercial nodes.

The commercial gas network model enables transformation of data not only in the above mentioned case, but also in other cases.

4. Capacity calculation

Different forms of gas transport system capacity calculation are necessary for several commercial business processes to support the decision making process. They can be summarized in 4 different tasks of capacity calculation:

- Free capacity calculation (technical, available)
- Booking request validation
- Nomination validation
- Other (helping in scenario design for network expansion studies).

Capacity calculation method accepted by Plinacro consists of 3 steps:

- Selection of basic parameters for simulation and scenario generation
- Capacity calculation by iterative gas transport system simulation procedure
- Simulation results processing.

The first step is executed by the commercial user within the environment of the Commercial Gas Transport Management system. A special programming tool, the scenario generator, takes input commercial data from the commercial database and prepares data for execution of simulation. So prepared set of data is called scenario and it is stored and maintained in the commercial database. Generated scenarios consist of:

- Scenario ID and name,
- Network model name,
- Initial boundary flow profiles,
- Maximum flows, maximum and / or minimum pressures,
- Prorating factors,
- Control variables.

Initial flows profiles, maximum flows and prorating factors are given by physical network supply and off-take nodes.

Second step is executed under the control of the specialized SIMONE user in the environment of SIMONE programming system. Roughly, there are 3 phases in execution of simulation:

- Data preparation
- Execution of iterative simulation procedure
- Review of simulation results and export to the commercial database.

Within the data preparation phase, SIMONE user performs following:

- Imports scenario from the commercial database,
- Selects a gas network model from the repository,
- Creates SIMONE execution scenario,
- Prepares and checks parameters for prorating algorithm,
- Makes some manual interventions in the network model, scenario or prorating parameters, if necessary.

SIMONE execution scenario is created on the basis of:

- Boundary flow scenario imported from the commercial system,
- Common constraints scenario,
- Common controls scenario,
- One of control variant scenarios.

Gas network models are developed and maintained within SIMONE tool. In the Commercial Gas Transport Management System, gas network models are registered by capacity calculation task, their SIMONE name, status and validity information (valid from – to).

On the contrary, basic data for construction of a scenario are kept and maintained in the commercial system database. Additional data for scenario generation (common constraints, common controls and control variant scenarios) are kept and maintained within SIMONE system.

This concept enables every commercial user to manipulate only with commercial data – i.e. entry and exit flow profiles. On the contrary, simulation will be done on the model from the real network; such a model can be very complex containing a large number of off-take stations. The usage of a copy of the real-time gas network model (LIVE) is recommended to obtain the basic gas network model for capacity calculation. Using the basic network model we can build expanded gas network models coordinated with future network expansion plans. These models form a model repository and they are maintained by an experienced SIMONE user.

All these models contain gas network control elements (regulating valves, compressors, etc.). It is essential to determine a proper set point value scenario(s) for simulation execution. Controls are divided into 2 scenarios: common controls and control variant scenarios. Control scenarios are also maintained by an experienced SIMONE user. The commercial user has only to select one out of several control variant scenarios. Introduction of control variant scenarios enables the user to calculate capacities in different network control regimes (like winter, summer, transitional, etc.).

Block diagram of capacity calculation is shown on Figure 4.

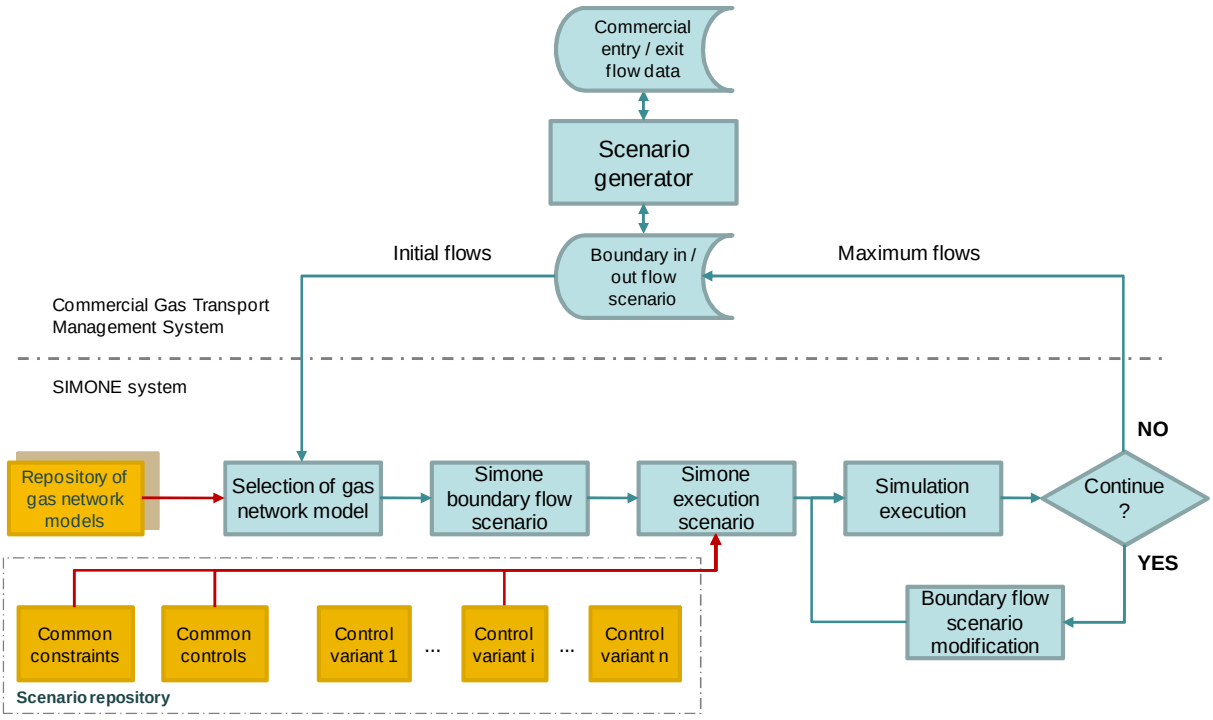


Figure 4: Capacity calculation block diagram

There are 2 distinct SIMONE applications performing tasks of capacity calculation / validation:

- SIMONE Capacity Tool for available capacity calculation and booking request validation
- SIMONE on-line for nomination / renomination validation.

In the first case the boundary flow scenario is prepared on the basis of booked entry / exit capacities for a particular period of time (season, month, etc.). Simulation can be performed for static or periodic day dynamic simulation. In both cases booked capacities are used to determine initial flow values per hour. In case of periodic day scenarios booked capacities are understood as daily average values that are additionally modulated by daily profiles obtained from historic values for particular off-take stations. In both cases in-take and off-take flows have to be balanced. If the dynamic simulation is used with periodic day scenarios,

simulation is repeated until the terminal state is sufficiently close to the initial state. These simulations are executed on a special SIMONE instance for capacity calculation.

Transport capacity of the gas network is calculated iteratively. The simulation always starts with an initial flow scenario. After successful execution of simulation scenario in-take and off-take flows are increased in prorating algorithm. Parameters for prorating are supplied within the scenario from the Commercial Gas Management System. After that simulation is executed again. This process is repeated until some hydraulic limitations are hit. Flow values of the last successfully executed scenario represent gas transport system capacity. This algorithm is described in the paper (Lit. 2.).

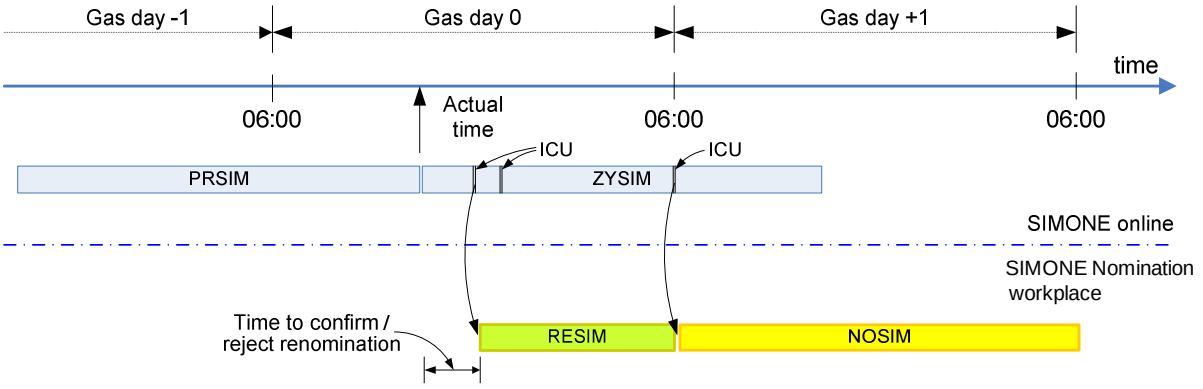
The SIMONE user can analyse calculated capacity, and, in some cases, can repeat iterative procedure more times with different prorating factors or different maximum flow values. After that the user initiates transfer of simulation results in the commercial database. Data transferred into the commercial database are structured in the same way as input initial boundary flows.

In the Commercial Gas Transport Management System simulation results are used to update generated scenarios. Than the commercial user has to initiate reverse transformation converting simulation results into commercial gas transport capacities, structured by commercial entry and exit nodes.

5. Nomination validation

In the second case SIMONE on-line system with additional workplace for is used for nomination / renomination validation. Here, nomination / renomination data are used as a basis for scenario generation. The procedure of nomination validation and communication between SIMONE and Commercial Gas Transport Management System are the same as described in previous chapter.

Any generated scenario for nomination validation is always of the dynamic type. If in some cases nomination contains daily average flows instead of hourly flow profiles, corresponding scenario entries will be generated by nominated value modulated by a typical daily profile of a particular off-take station, calculated from historical data. The scenario foreseen for nomination validation is 1 day long, starting on the next gas day at 6:00. On the contrary, the renomination scenario lasts usually shorter than 24 hours, and it is applied to the rest of the actual day, starting at a certain moment (e.g. 2:00 p.m.) when the renomination collection process is already terminated, and ending at 6:00 in the next morning.



Legend:

PRSIM	- realtime simulation scenario
ZYSIM	- «Look-Ahead» simulation scenario
NOSIM	- nomination validation scenario (for the next gas day)
RESIM	- renomination validation scenario (for the rest of actual gas day)
ICU	- complete state of gas transport system model

Figure 5: Different scenarios for nomination / renomination validation

The initial state for nomination / renomination validation is taken from Look-ahead simulation. For that purpose, complete network states (ICU) are saved on the hourly basis in Look-ahead simulation imposing a limitation on the initial time of the renomination validation scenario – it can start on the exact hour only. This limitation is in accordance with the renomination business process specification. Time relations between different scenarios executed in SIMONE on-line instance are shown on Figure 5.

Unlike capacity calculation, the nomination / renomination validation process is executed only once. The result of simulation execution is a logical variable. If some hydraulic limitation is violated during the simulation, the result will be »nomination rejected«, and in the opposite case, the result will be «nomination accepted».

6. Integration description

OTS Plinacro has decided to integrate all company IT resources. Integration of IT resources has to be done according to principles of the service oriented architecture (SOA). Implementation of SOA principles is based on web service usage. IBM WebSphere product has been selected as the basic technology for integration implementation.

A simplified and incomplete diagram of integrated IT resources is shown on Figure 6. Internal and external users access applications through the common company portal. To access the portal, different communication media are be used: LAN, Intranet, and Internet.

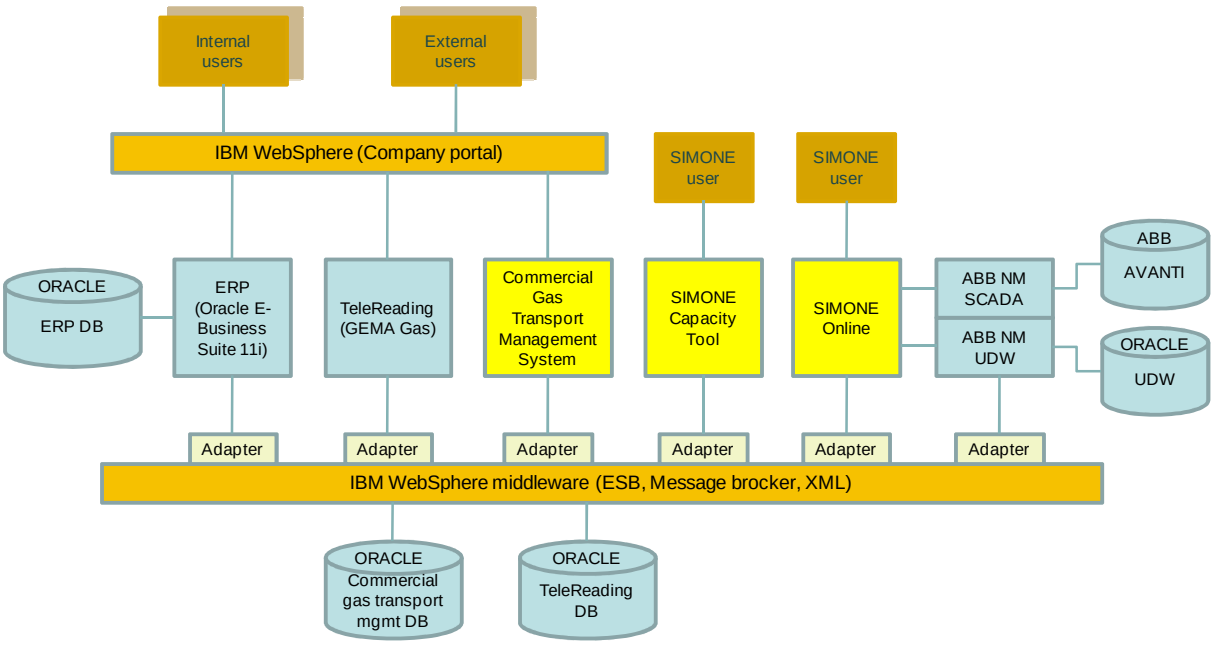


Figure 6: Simplified block diagram of integrated IT resources

Enterprise Service Bus (ESB) is used for communication between different applications. An appropriate adapter for ESB will be developed for each application.

Using the stated communication solutions the following components will be integrated into the commercial gas transport management system:

- TeleReading system,
- ERP Oracle e-Business Suite 11i
- ABB UDW data warehouse
- SIMONE Capacity Tool
- SIMONE on-line.

For the purpose of this paper, the most important fact is the way in which communication between the Commercial Gas Management system and SIMONE applications is going to be realized in practice.

The capacity calculation procedure has several steps including also communication among different applications:

- Commercial user invokes the scenario generator, when he has selected parameters for capacity calculation,
- Scenario generator reads appropriate data from the database and constructs a scenario. The scenario is stored in the commercial database. In order to perform a particular capacity problem, commercial user can generate a batch of scenarios,
- Special SIMONE user is notified and asked to perform capacity calculation,
- SIMONE user reads the generated scenario (or batch of scenarios), performs calculation and returns calculation results to the commercial database,
- After scenario records are updated with calculation results, the scenario generator performs a backward operation, i.e. transforms calculated maximum physical boundary flows into maximum flows by commercial entry and exit nodes.

Communication between SIMONE application and the commercial application contains mechanisms that enable SIMONE user to perform following functions:

- Navigating through the list of generated scenarios
- Reading selected scenarios from the commercial database
- Transferring calculation results to the commercial database, when SIMONE calculation is performed.

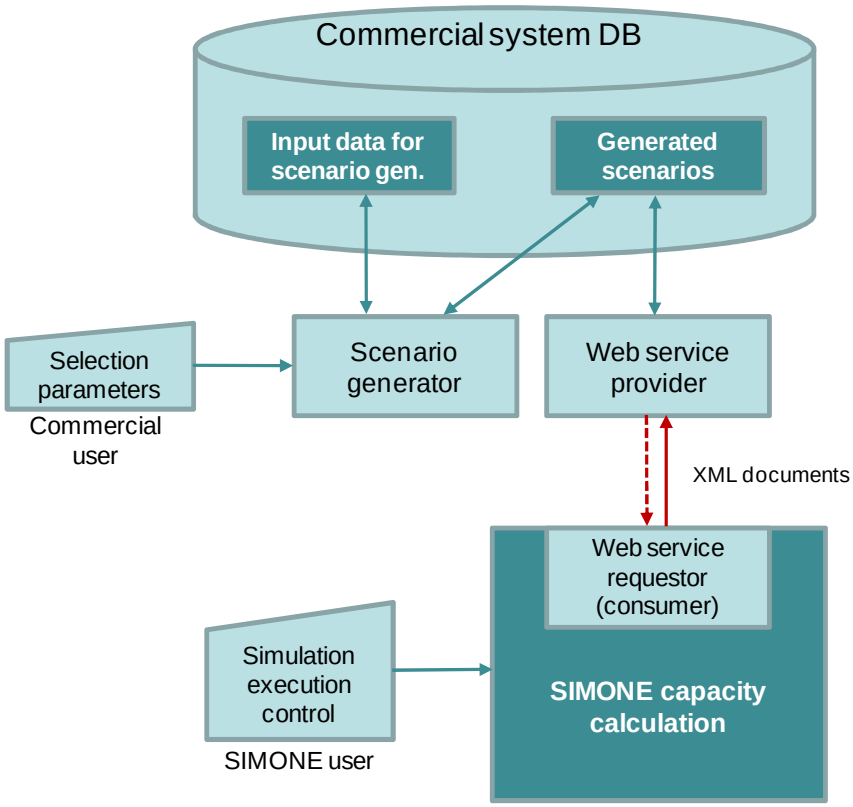


Figure 7: Data exchange between SIMONE and Commercial Gas Transport Management System

Data exchange between SIMONE and the Commercial Gas Transport Management System (shown on Figure 7), that takes place behind these functions, is performed by means of web services exchanging XML documents. Access to scenario data in the commercial DB is enabled by a special web service provider, developed within

the commercial system. Within the SIMONE capacity calculation program there is a web service requestor (or the consumer). Both web services are able to create XML documents and retrieve data from corresponding XML documents. Data is exchanged on the basis of the request / response principle.

7. Conclusion

On a liberalized gas market, capacity of the transport system becomes a very complex commodity that is offered and sold by TSO to market participants. Therefore, this commodity is the subject of many different commercial transactions. First of all, TSO has to »meter« gas transport capacity, i.e. to gain quantitative knowledge on gas transport capacity.

Metering is possible by means of simulation tools only, and it produces quantitative figures of gas transport capacity, which represent, on the other hand, the basis for all the other commercial transactions.

SIMONE has been present on the market for a long time, as an established leader in delivering of gas network simulation solutions. Therefore, OTS Plinacro has selected SIMONE solution as the basis for capacity calculation and validation applications.

SIMONE application, designed to produce solutions for standard gas network simulation tasks is extended with functions for gas transport capacity calculation in both off-line and on-line mode. SIMONE application comprises its own database containing mainly data on network models, scenarios, and calculation results. When SIMONE becomes a part of a larger IT system it has to exchange data with other applications. In case of SIMONE solutions applied to TSO Plinacro, gas network models are maintained exclusively within SIMONE environment, while data for scenario construction and simulation results are exchanged with external applications. The modules for that communication are based on application of SIMONE API functionality.

In order to enable integration of SIMONE into Plinacro IT system, two major problems should have been solved:

- Development of a commercial gas transport model to facilitate data transformation and interpretation,
- Selection and implementation of appropriate application integration technology.

As long as the communication between SIMONE on-line and SCADA is based on »one-to-one« data mapping, data mapping between the commercial gas management system and SIMONE is much more complex. Therefore, a commercial gas transport model is developed and used to translate commercial quantities, like entry / exit capacities, nominations, etc., in physical in-take and off-take flows necessary for scenario construction for simulation execution. Similarly, calculated in-take and off-take flows are transformed in figures that are understandable to commercial users.

The integration of all IT resources in Plinacro, including the Commercial gas transport management system and SIMONE, is based on the principles of the service oriented architecture (SOA). Web services exchanging XML documents are introduced as a new layer enabling communication among different applications.

In both SIMONE instances (SIMONE capacity tool and SIMONE on-line) special web service requestor (consumer) modules have been developed based on SIMONE API application. These services communicate by exchanging XML documents with the corresponding web service provider within the commercial gas transport management system that enables access to the commercial system database.

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