White Paper

Intelligent Solutions for the Process Industries

Data Flow & Business Process Modeling

For

Manufacturing Operations Management

Abstract

Level 3 Systems in the Process Industries represent IT applications that enable automation of operational activities and facilitate decision support.
Such systems are integrated with Level 2, 1, 0 Systems (Process Control and Field Instrumentation Systems) and with Level 4 Systems (Enterprise Resource Planning Systems).
Level 3 Systems are commonly referred to as Manufacturing Execution Systems (MES), Manufacturing Operations Management Systems (MOM), or simply as Decision Support Systems (DSS).
In practice, Level 3 Systems is a suite of integrated applications consisted of "point solutions", as for example applications for Production Planning and Scheduling (PPS & PSS), Data Validation and Reconciliation (DVR), Lifecycle Reliability and Integrity (LRIS), etc.
The development of Level 3 Systems requires clear definition of work and data flows upfront, during the Front End Engineering & Design (FEED) phase of such systems. Work flows (also referred to as Business Processes) take into account organizational practices, roles and responsibilities of staff. As the level of integration of Level 3 Systems is critical to the successful implementation and use of these applications, it is also critical to thoroughly study and model the integration of these systems in a way that ensures integrity and consistency amongst the users, between such practices and the use of data itself.
In most cases, representation of work and data flows is represented by static, non – intelligent drawings and sketches. This approach unfortunately carries inherent limitations in maintenance and management of these models.
Recently, Business Process Modeling Notation (BPMN) – based software tools have been also used. The limitation in this approach is that the resulting models do not provide consistency between data and work flows. On the positive side, there is a fairly good integration of practices and allocation of roles and responsibilities.
Dynamic modeling of data and work flows is an alternative approach. By dynamic modeling, it is meant that there are dynamic relationships and links amongst the various components of such model in the form of data, interfaces, users and scenarios, which represent procedures and activities assigned to users. It is also noted that by components it is meant the actual systems or application included in the Level 3 System Architecture designed for a specific facility, like a refinery or petrochemical plant.

This paper presents the means to generate such dynamic models, through use of the Dynamic Asset Documentation system (DAD), while ensuring integrity between the data interchanged between the various Level 3 Systems, as well integrity in the use of the data and work flows by specific users and in specific user scenarios.

Introduction

A typical MES or MOM System adheres or adopts the principles of a 3 – tier architecture as defined by the ISA – 95 model presented below.

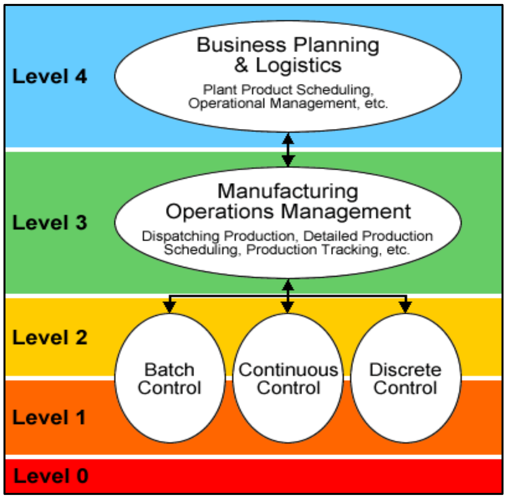

Figure 1 - ISA 95 Model

A comprehensive MOM system can include numerous applications as noted in the example below:

Table 1 - Example of Level 3 Applications

Production Planning System
Production Scheduling System
Data Validation Reconciliation System
Lifecycle Reliability & Integrity System
Health, Safety & Environmental System
Decision Support & Visualization
Etc,

A fully integrated MOM system may also include other systems which need to be functionality and physically integrated. These systems may be provided as part of the Level 2, 1, 0 (Process Control Systems – PCS) environment and include such systems as Distributed Control System (DCS), Advanced Process Control (APC), DAHS (Data Acquisition and Historian System), etc.

The integration approach or implementation strategy requires that all these systems, from all layers need to be defined and modeled as a totally integrated solution as, for example, shown below.

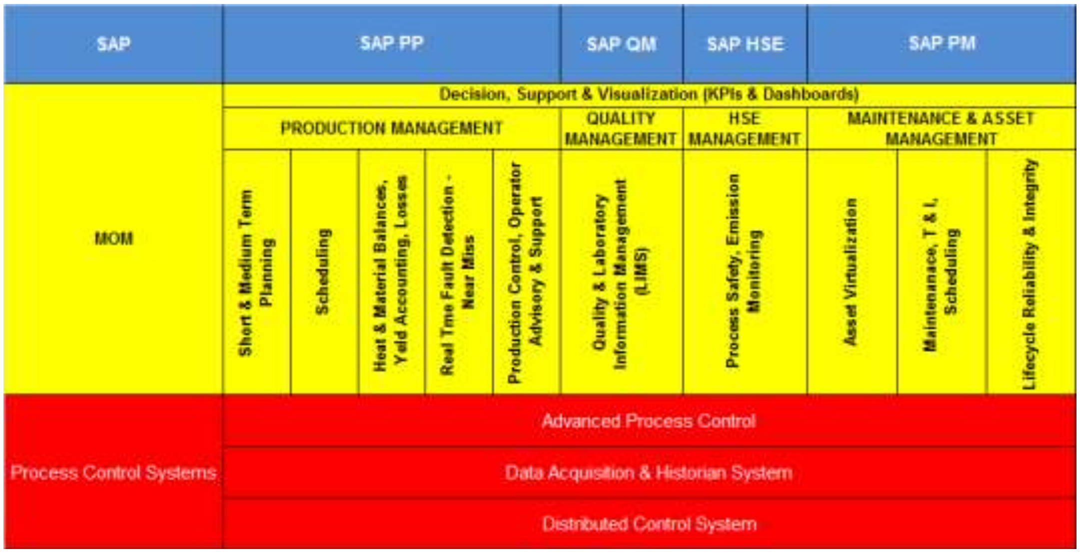

Figure 2 - Landscape of MOM Applications

DAD Model Development Methodology

As noted previously, DAD is used to model components, data flows, work flows and scenarios, functionalities, users, etc. While the definition of MOM functionality can be user driven, the MOM DAD modeling methodology applied in this example assumes certain standard functionalities exist within each MOM module/component. As such, the first step of a series of modeling steps is to define these components and functionalities. All modeling steps are performed through use of DAD standard functionalities as follows:

Definition of Components & Functionalities

As noted earlier, components represent the systems and/or actual applications and functionalities for each ISA – 95 Level system or subsystem in a “tree hierarchy” and “parent – child” relationships as indicated in the figure below.

Figure 3 - Definition of Components

Each major component is defined at a higher level (i.e. SAP, PCS, MOM) followed by its "children", which are functional applications and modules contained in each component "parent". At the lowest level, functionalities are defined as component "children" shown in the previous figure (see example for the Real Time Fault Detection – On Line Fault Predictive Model (OFM) component, which has such functionalities as Collect RT Data, Load KPI Boundaries, Generate Prediction, etc.).

Definition of Connectors (Data Flows and Links)

Once the components and functionalities are defined, data flows or links are configured in the model. These are practically connectors between components in the case of physical models, or functionalities in the case of logical models. Each connector is defined with a specific direction (>), indicating the "from"/"to" interchange of data as indicated in the figure below.

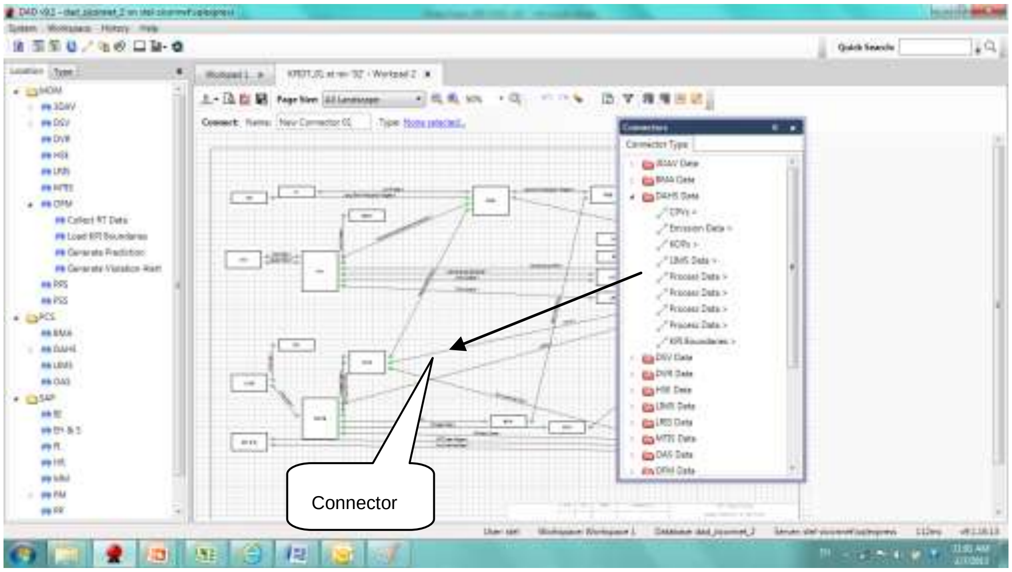

Figure 4 - Definition of Connectors

Connectors are defined and dynamically drawn as links between systems. These connectors represent practically data transferred between components. The means of data transfer is irrelevant and addressed during detailed design. In this example, the model in the above figure has been generated dynamically based on a component – specific list of connectors shown below.

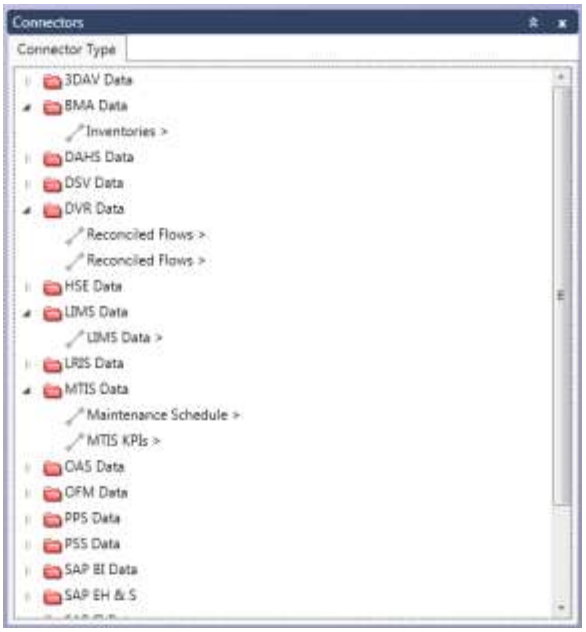

Figure 5 - Definition of Connectors

At any time during the work and data flow modeling process, the list of connector names and types can be generated and exported to MS Excel, edited and imported back into the DAD model as shown in the next figure.

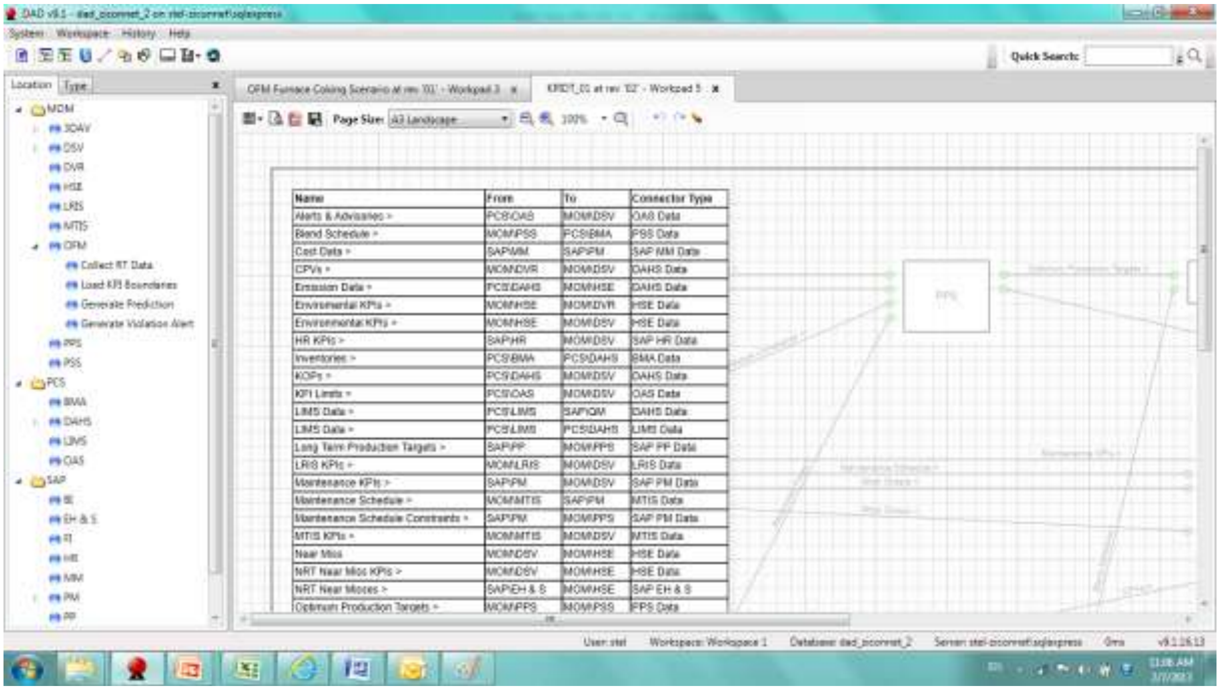

Figure 6 - Generation of Connectors Table

Definition of Scenarios

Scenarios are defined as work processes consisted of functionalities provided by the MOM subsystems. These scenarios represent operational situations supported by MOM. The definition of scenarios is done by “drag and drop” of the functionality under a component to the defined scenario, and once this operation is performed, a scenario will be defined as shown in the figure below (Furnace Coking or Compressor Surge).

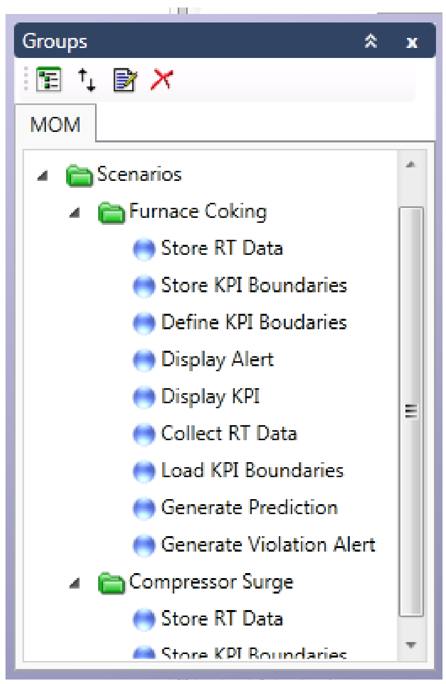

Figure 7 – Definition of Scenarios

Once the functional components for a scenario are assigned as noted above, the graphical representation of the scenario can be generated in a DAD Workpad as shown below. The Workpad can be saved as a pdf file and edited at any time.

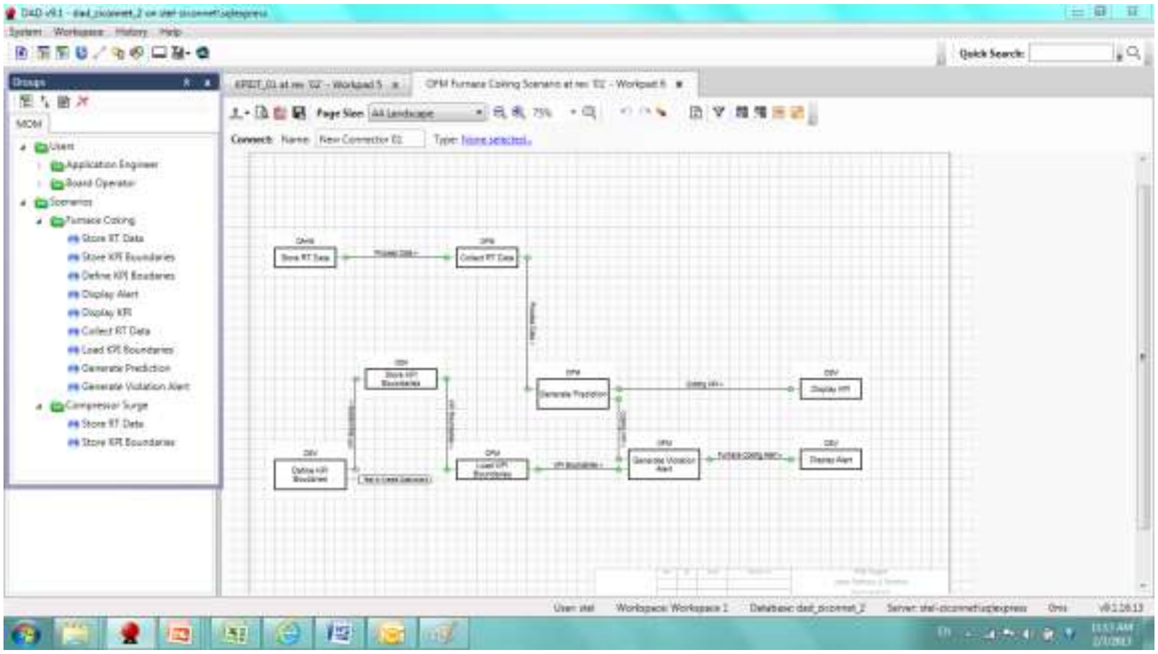

Figure 8 - Scenario Data Flow

It is important to note that in the graphical presentation of the scenario includes both the physical/logical allocation of the functionality. For example, in the above example, the Store RT Data functionality is performed in the DAHS, while other functionalities are performed in other systems as noted above its function in the above figure. As such, scenarios are generated as a combination of functionalities provided by multiple MOM subsystems.

Definition of Users

Once the components, data flows and functionalities are defined as described previously, the MOM FEED needs to address the MOM users and their specific functionalities assigned to these users. This means that functionalities previously defined for each component (in essence a physical model) are now assigned to MOM users (users can use the same functionality, or a functionality can be assigned to multiple users).

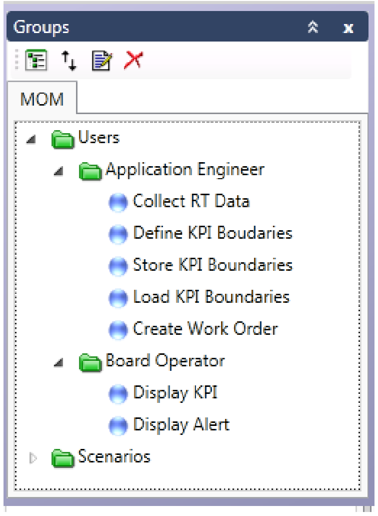

Figure 9 - Definition of Users

The definition of users and scenarios, as well as the allocation of functionalities to scenarios and to users occurs in a single environment called Groups as shown below. This ensures consistency between all aspects of this modeling approach, including Components and Functionalities, Connectors, Scenarios and Users.

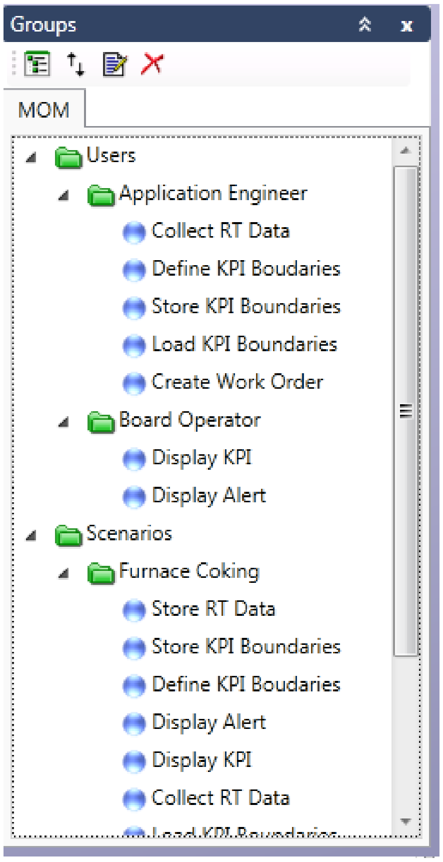

Figure 10 - Grouping Functionality

Conclusion

The challenge of data flow and work flow modeling during the FEED phase of MES and MOM systems is substantial when it comes to consistency and efficiency.

A typical MES/MOM project may consist of tens of subsystems, tens of types of users and hundreds of data flows. Scenarios may also result into hundreds of related diagrams, containing all the details of logical and functional blocks of various systems.

The presented approach assures that such consistency is maintained, while reducing the cost of documentation and the lifecycle management of models to a fraction of the traditional approaches, which typically use static drawing tools or even a combination of BPMN –based tools with data flow diagramming tools.

About the Author:

Stelios Kentritas is an Advanced Process Solutions consultant with >30 year career mainly in the process and IT industries and in the development and implementation of process control systems, process systems, dynamic simulation, advanced process control, information management, manufacturing execution and supply chain management solutions, data warehousing and data mining systems, business intelligence and decision support systems, geographical information management, CAD/CAM/CAE, facilities management and photogrammetric systems for land information and cadastre applications.

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