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Web-based Operator Training System

Manel Serra[a], Erika Franco[a], Luis Rumi[a], José M. Ferrer[a], José M. Nougués[a]

[a] *Inprocess Technology and Consulting Group, S.L., Gran Via de Carles III, 86, Barcelona, 08028, Spain*

manel.serra@inprocessgroup.com

Abstract

Producing plants must be safe and reliable. Plant Safety is strongly dependent on how well people responsible for running the facility (control room operators, CRO) is aware of its operation. Improving the understanding and awareness is the goal of any training to CROs, hence, their trainings must be carried out in an environment as similar as possible to the one they will find in their work, like airplane pilots do with flight simulators, in order to be minimally qualified to carry out their job tasks. And this is the objective of the Operator Training Systems (OTS)[1]: deliver training to CROs in a replica of their working environment, maximizing its effectiveness. Matching the availability of the training facilities (comprising instructor) with the one of the CRO can be crucial in easing to achieve an on-time learning activity. That's why, in the traditional approach to the OTS, these training systems live in a training room, typically close to the actual control room they emulate.

The universalization of internet connections, even in the most remote locations, and the evolution of the software technologies to support and enable mobility bring new opportunities to training systems. Those OTS systems that had to be physically deployed at every site where operators were trained can now be remote by combining some of the latest developments: e-learning standards (like the well-established SCORM[2] or AICC), sound software applications used to develop and deploy OTS (dynamic process simulators, control system emulators...)[3] and the latest technologies on virtualization. This distributed framework does not only facilitate scalability of the training sessions or overall system maintenance, but it also grants access to comprehensive training to more people in many different conditions, even to people in the same company that are in charge of similar processes. The return of investment in training and education is then maximized by easing the access to many more people.

With this new infrastructure it is also possible for companies which will not usually look into developing a fully fledged OTS because of its cost, to get access to subscription type of trainings, where, for a fraction of the cost for an OTS, they can train their operators in rigorous plant models, closely resembling their actual plants. Analysis show that, the usage of OTS improves operator effectiveness in 31% [4]; the usage of the new web based OTS, even when working with a similar model and not the actual, it is able to capture most of the value of a traditional OTS.

The advantages of the new solutions also bring the possibility to process licensors to even demonstrate in practical terms the benefits, characteristics and actual operation of the licensed processes to actual and potential clients.

The OTS solution presented here takes advantage of a software architecture which increases and distributes the availability of the training facility, enabling its access to

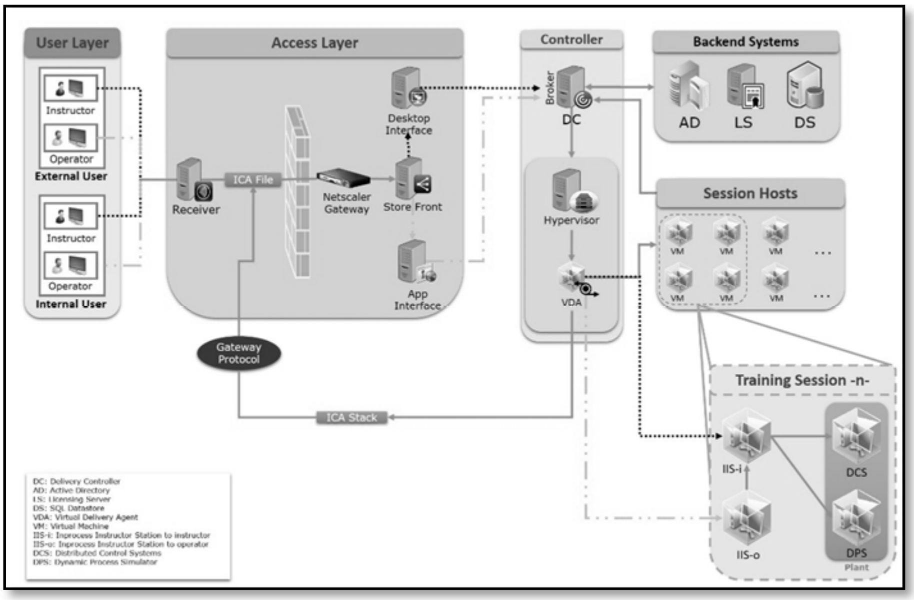
CROs from other company sites, from other time zones, and even from outside the company premises. This solution has been implemented and used by a European plant operator training institution, and two European chemical process licensors.

Keywords: Training, operator, OTS, simulation, dynamic simulation

1. General Architecture

In the last years, there have been many intents to deploy Dynamic Process Simulator through web based applications[5]. However, the Distributed Control System (DCS), one of the component of OTS, are based in a complex architecture with many software layers which each vendor implements following different approaches; and it's been this complexity which has prevented new deployment models until now. With the new development of software technology and protocols in the cloud computing [6], Inprocess has been able to distribute the usage (and hence, also the benefits) of OTS tools. In this section, a generalized architecture for a distributed OTS based on a virtualized, scalable and flexible environment is described.

Essentially, the distributed OTS platform presented is a virtualization software based solution that allows access to the individual applications of the system (such as operator screens) through individual user devices and from a shared server. The installation for the remote training platform contains several elements that relate to each other and to the users that access it, as depicted in the following diagram.



To start a session the user (Instructor or Operator; differences will be explained in the role-based section) accesses the infrastructure via a Receiver. The Receiver is a software (which may be locally installed or web accessed) from where the user selects the physical or virtual desktop or virtual application that is available to his/her role.

To determine resources available to a user, credentials move through the Access Layer to the Controller, the central component responsible for distributing applications, managing user access and optimizing connections. The Controller determines what resources are needed/available by communicating with a Broker Service, in charge of managing which users are connected, which resources are using and manage their connections, determining which desktops and applications a user is allowed to access.

Once the credentials are verified (by means of the Active Directory, AD), the information about available apps or desktops is sent back to the user through the StoreFront-Receiver pathway. When the user selects applications or desktops from this list, that information goes back down to the Controller, which determines the proper VDA (Virtual Delivery Agent) to host the specific applications or desktop.

The Hypervisor hosts the virtual machines with the corresponding software, configuring one or more training sessions. Each training session contains a representation of a process or plant (in the form of a DPS model and the associated control logic, typically an emulation of a DCS); it also contains the applications used by users to interact with the plant and the training.

The Controller verifies the license of each software hosted in the Hypervisor (contacting the relevant License Server, LS) and grants access to the authenticated users.

The Domain Controller (DC) sends a message to the VDA with the user's credentials and the data about the connection. The VDA accepts the connection and sends the information through the same paths to the Receiver. All this data is stored in the Database (DS), along with other parameters defined (such as machine site directives, machine catalogs or delivery groups), can be reported for system monitoring purposes. This database is also used to store training-related information: data generated by operators which allow their monitoring and eventually the evaluation of their performance in the training session.

In the way back to the user, the Receiver bundles up all the information necessary to make the user's connection to published resources generated in the session to create an Independent Computing Architecture (ICA) file. Credentials remain encrypted throughout this process.

The ICA file establishes a direct connection between the device and the ICA stack running on the VDA. The management infrastructure that facilitated the connection is no longer used at this point (elements such as the StoreFront or the Domain Controller).

The connection between Receiver and the VDA uses the Gateway Protocol. If a connection is lost, the Session Reliability feature enables the user to reconnect to the VDA rather than having to relaunch through the management infrastructure.

Once the user connects to the VDA, the VDA notifies the Controller that the user is logged on, and the Controller sends this information to the Site database and starts logging data in the monitoring database.

2. Role-Based Architecture in use

The architecture described supports the different workflows required: from configuration of a training session, to its actual monitoring and operation. This section explains how these workflows are realized.

To configure a training session, an Instructor logs into the system and defines from its control panel the components for the training session from the ones available in the system; that is, the instructor selects the virtual machines containing the elements of the

Virtual Plant to be used in the session (e.g. one machine with DPS "A", which will run the proper configured case, and one machine with DCS "X" emulating the relevant control logic), and their configuration files. The system assigns directly an instance of an Instructor Workstation (IIS-i), which is not only a front-end for the instructor, but also the framework communicating the different elements of the session together.

To activate a training session, the instructor selects one of the preconfigured sessions (either by himself or by another instructor), and then selects the users that will act as operators (from the AD); if the training is to be conducted through internet, and not internally from the company network, a slightly longer procedure is required to achieve the final access (this is typically managed through a previous registration process, where the instructor or another system administrator needs to obtain first the email addresses of the attendees to enable the new profiles and the external access; however this is the only practical difference between an external and an internal access, since even the instructor could be made external). The system then activates the different components of the session and returns an Instructor Workstation display to the instructor to control and monitor the training. At the same time, users defined by the instructor as operators logging into the system find an icon in their computer to connect to an Operator Workstation (IIS-o) assigned to them by the system. Operators are not able to interact with the instructor features, unless the system is configured to run self-trainings.

3. Functionalities and Benefits

In its most usual current configuration, an OTS is a system with a dedicated set of hardware, software and licenses hosted in a specific room: every OTS has its own physical space and resources assigned. In many occasions, multiple OTS of different units in a plant may reuse the same hardware, some of the licenses and even training facilities; however, it is very rare that OTS from different plants, even when being operated by the same company share the OTS resources. Even more, it is unusual for people from other plants to travel to other sites for training in an existing OTS of a plant which may resemble their own. And having a replica of a physical OTS is not something as easy as one could think.

With the architecture proposed, a change in the paradigm of OTS usage is possible, as it tackles the constraints and some of the issues in the traditional deployment of these complex training systems. The advantages show up in different areas, which are described in some more detail below these lines with references to specific cases; these areas are: distribution / reach of the tool, scalability, deployment flexibility and maintainability and security. Link to e-learning platforms is also discussed.

3.1. Distribution / Reach of the Tool

One of the key advantages is the new possibilities in terms of who can use and when a deployed OTS, that is, the distribution and reach of the tool. With the traditional approach, the OTS usage is limited to the people who can physically sit in the OTS room. Enabling the remote use, that is no longer a limitation: any person who is granted access to the system can be trained in the OTS from anywhere in the world. That was one of the drivers identified by one of Inprocess' clients, a European process licensor. This company evaluated the possibility of using an OTS as part of the internal training programme for its engineers. The option of enabling its engineers from any of their offices to benefit from this training without incurring in additional travelling charges or without planning complex schedules helped decisively in the approval of the investment. Even more, taking advantage of time differences between offices around the globe, the same software licensing and hardware infrastructure supported more than one single full training session in a given day, optimizing the use of the resources.

3.2. Flexibility

But there was something else that this process licensor valued from the new approach, and it was the flexibility of the system. Flexibility not only in enabling internal or external users to connect to the system, either from work-place or home-based; not only supporting both classroom type of training and self-training; but also the off-site use of the OTS even without connection to the headquarters. The system described is light enough to be able to fit in a portable computer and can be used as a sales support tool in front of customers, showcased in events or even used for off-site trainings. No installation time, no cumbersome configuration at customer site: just power on the portable system, connect any customer computer to be used as thin client, register the new users and activate the training; as simple as it sounds.

Another area of flexibility is enabling the cross-platform usage of the training tools: as the final front end to the user becomes a type of web interface, with no actual need of a high end supporting hardware, users may connect to the system using many different devices, including high resolution tablets.

3.3. Scalability

Another of the strong points of the architecture is its scalability. By basing the system in a set of virtual machines, these are easily and quickly replicated, allowing for multiple instances (replicas) of a training session to be run in parallel (as many as the licensing or the available hardware allows). This advantage was one of the drivers for an European plant operator training institution to adopt this solution: with this technology, operator stations can be created on demand based on the number of students per class, along with a simple infrastructure that allows activating quickly multiple training sessions (i.e. different processes, or same process at different conditions) in a common classroom.

Both the scalability and flexibility of the system offers an opportunity for companies with limited training budgets to get access to best-in-class operator training from providers such as Inprocess. In this case, generic plant unit OTSs are made available on a subscription basis. This commercial model, enabled by the described architecture, saves especially to smaller companies with a reduced staffing the development time and upfront costs of a full, customized OTS, which would not be fully utilized to its potential, converting it to a pay-per-use model accessible to their training departments.

3.4. Maintainability and Security

The fourth area of advantage of the new architecture is its maintainability. Using well established software tools and especially virtualization, the maintenance of the system from the IT point of view is streamlined, as backups, restores, software updates and other maintenance tasks are accomplished in an efficient and well established manner. Hardware and software resources are also more efficiently consumed.

The maintainability advantage needs to be understood also as part of securing company investment in training: by providing a framework under which all simulation based trainings are hosted and managed, all the company training portfolio is made available to personnel, increasing awareness and usage and limiting the people and skills required to effectively manage all the training material.

All the advantages listed above would fall short in the light of today's security risks. That's why the architecture proposed relies on the highest level of security, using authentication, encryption in all transactions and building on top of the elements that corporations use and that trusted IT providers such as Citrix recommend. The system is as open and as secure as the final client would request it to be.

3.5. E-Learning

But the benefits of this approach do not end with the above four areas. Since the usage of the system is powered by network browsing mechanisms, and the final visualization may be rendered in HTML-5 pages, this architecture is just a step away of being integrated in a Learning Management System. E-Learning standards (such as SCORM or AICC) provide guidelines on packaging and deployment of web content to form a training module or a complete training programme. The OTS architecture provided fits the deployment structure of these standards, allowing the access to the OTS from within the training modules themselves. One can see that, in the same training chapter in execution, the student, instead of using a "traditional" calculator just activates the link embedded as part of the content of the training module (e.g. start up of the plant, 2nd day) and is presented with the OTS interface relevant to the present chapter. The student executes the proposed exercises in the OTS and uses the results to answer questions in the training module, while the system logs additional information generated in the OTS side and stores it under the student profile for further / more detailed review of the performance of the student in the chapter.

4. Conclusions

Benefits of improved training are sound and a target in today's organizations. Realizing the potential of the investment in training tools is also a desirable objective. With the explosion of the networks, cloud based solutions and other technologies and the globalization of company operations, these two objectives can now be applied also to one of the most complex training tools, the OTS.

This paper presented a full architecture that has allowed Inprocess to convert OTS from the traditional physical training room tool, to a remote, web based experience. This architecture has been and is used to achieve benefits in distribution / reach of the tool, scalability, deployment flexibility and maintainability and security of OTS.

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