FRAMEWORK FOR INTEROPERABLE OPERATIONS IN PORT FACILITIES

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ABSTRACT

Among the most advanced techniques, interoperable simulation is actually emerging in those application fields where different entities/components dynamically interacts. Currently such a technology is becoming more and more effective in new areas, reproducing the experiences already collected in military sectors. For instance, logistics infrastructures and ports see many entities interacting dynamically, their synergy strongly affects the overall efficiency of the port terminals as well as the safety of the operators.
DIPTEM is involved in a new research, funded by COSMOLAB Consortium, for creating a distributed federation able to reproduce port operations with special emphasis on the dock cranes; in fact DIPTEM collected over the last five years multiple experiences in this sector and in bordering areas: SITRANET and INNOVARE researchs for Intermodal Terminal, RESET for River Logistic.

CYBERSAR FEDERATION FOR PORTAINER SIMULATION

The aim of the research is to simulate the behavior of intermodal equipment (cranes, stackers, trucks etc.) through the development of federates characterized by the capabilitiy to operate stand-alone or to be integrated in the HLA federation for cooperating. In such way, different trainees are able to work together in order to simulate real cases and complete missions. Consider a crane operator moving a container from a ship on a truck, driven by another operator, a third one is expected to move the container on a free area of the terminal using a reach-stacker simulator. Monitoring and supervising the results of the mission and operating both in LAN both in WAN the operators can act as previously described; in general sense not only driver simulators have to be integrated, the DIPTEM applied DIS in their past researches in order to create training exercise for managers/planners (i.e. dock manager, yard planner, control room, etc.). In the same way it is possible to integrate in the Federation also these entities directing the operators, providing support for testing policies and procedures.
The interaction among the terminal vehicles as prime cause of accidents and injuries in port operations has to be stressed; at the same time the handling policies and procedures are the key factors for improving productivity and safety. Based on such a consideration it is clear that past experiences in extended application in military sector combined with new technologies enabling low cost simulation, allow to export these

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experiences in new areas, such as port training or industrial facilities.
The proposed case is related to the development of a federation focusing on the Portainers or dock gantry cranes: big equipment devoted to load/unload container ships.
The proposed integration among simulators is based on HLA (High Level Architecture) while the simulation engine is developed by the DIPTEM.
The proposed engine guarantees to have simulators fully scalable combining different federates in order to distributed/construct complex combinations (i.e. distributing heavy computational workload among federates); the most complex cranes are equipped of static mock-ups (i.e. port truck drivers) and full motion 6Degree of Freedom simulators. The design of the entire architecture needs special attention, actually the configuration is based on:

- one full scope simulator
- 6DOF motion platform
- advanced visualization solution integrated with eye tracking system (crane operator)
- interactive pilot station
- workstation
- large screen (truck drivers)

The system is installed in a shelter for easy mobility among different sites, this configuration includes:

- full motion station
- 3 basic stations
- instructor station (re-configurable for driving a vehicle)
- 1 panoramic observer station

Therefore the system is designed to be combined with other shelters and to be reconfigured based on the necessities.
Another innovative aspect is related to the integration of ship motions with movement at docks as well as detailed elastic models of cables; these parts represent special federates operating on High Performance Computers remotely (WAN) in case of critical events/conditions simulation, or to be substitute by meta-model running on the local workstations (LAN) for regular training.
Also, DIPTEM is currently experiencing the integration of traditional training with simulation: based on blended solutions combining different kind of training equipment it is possible to operate in cooperative/competitive mode.

Figure 1: Mock-up motion platform

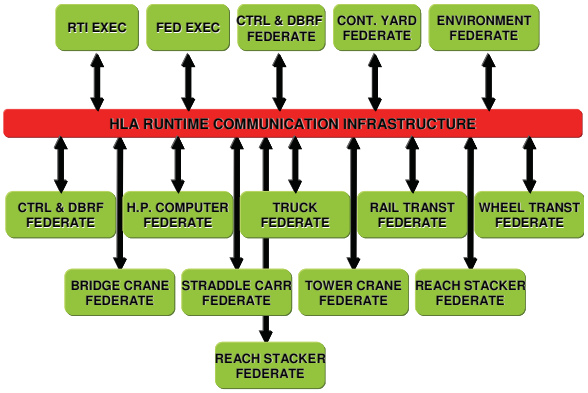

Figure 2: HLA Federation

VIRTUAL WORLD

The researchers have experienced new opportunities for applying Real Time Distributed Simulation, HLA-based, with special attention to Vehicle Driving and crane operation, taking into consideration the development of an ad hoc virtual world reproducing the entire Cagliari Port; the research obviously take into account several issues such as operative procedure definition, operators training & education, improvements on handling safety, improvements on operative efficiency.
Based on these inputs, the researchers developed the entire world including the surrounding areas, roads,

container yard, different type yard cranes, ship cranes, ships etc.
These world is integrated in the new generation of simulators oriented to the dissemination of simulation techniques as training tool in the logistics users community.

Figure 3: Virtual Yard with Virtual Cranes and Virtual Trucks

Figure 4: Portainers: Virtual Cranes operating on Ships

Figure 5: Virtual Ships with Four Portainers

Figure 6: Virtual Transtainer operating on the Yard

The researchers guaranteed that the virtual world was real-time, and emphasized the importance of creating a hierarchical structure of the objects in order to be integrated in the simulators; these are integrated over a LAN/WAN (Local Area Network/Wide Area Network) by using HLA (IEEE Standard and regulation for US DoD Simulators), this on the basis of HLA characteristics which make possible to realize an interactive real time simulation across a network.

Figure 7: The Whole Virtual World with Channels, Terminal and Roads

Based on such a choice a wide range of configurations and operative applications is possible, from operating stand alone on a single PC to creating a federation of cranes interacting in a networks.
The solution proposed is designed to allow dynamic reconfiguration of each PC in order to reallocate the equipment and to create different scenarios; obviously this is in some way limited by the availability of proper hardware device on a PC Workstation for driving/operating a specific vehicle.

Therefore by using simple game interface it is possible to configure a large set of position that can quickly changed from cranes to truck for creating complex cooperative scenarios; in this case it is also possible to define competitive operation where different team/squad are working concurrently in order to get better production.
The developed HLA configuration was designed in order to include several federates:

- Portainers federation allows the operator to practice a portainer in different scenarios. The operator can virtually load and unload container from a ship, in a virtual dock where different portainers work simultaneously. The portainer not in use by the operator is automatically under control of the simulator itself
- Control & Debriefing federation : the trainer can set such a federate every new training session. Trainer can change environmental conditions choosing different number of containers, of operative straddle carriers, number and type of ships in port and number of trains. This federation automatically controls all the trucks and carriers not directly used by operators and provides automatic traffic on the road around the intermodal node.
- Debriefing federate evaluates operator performance.
- High Performance Computer (HPC) Interface
- Yard Traffic Simulation controls traffic in the intermodal area
- Environmental Simulation: based on such a federate it is possible setting simulation starting time, weather condition, wind and sea condition included
- Truck, reach stacker, straddle carrier, wheel transtainer, rail transtainer, bridge crane, heavy crane federations improve the quality of the training session allowing the operator to drive different cranes in multipurpose operation.

In this case the users defined as critical the necessity to integrate also High Performance Computing facilities in the federation in order to guarantee real-time simulation of very complex phenomena (i.e. ship motion at dock and cable stress/strain).
Due to this necessity a specific federate was developed able to operate through simplified meta-models when HPC facilities are not available and to interact with the Supercomputing grid when possible.

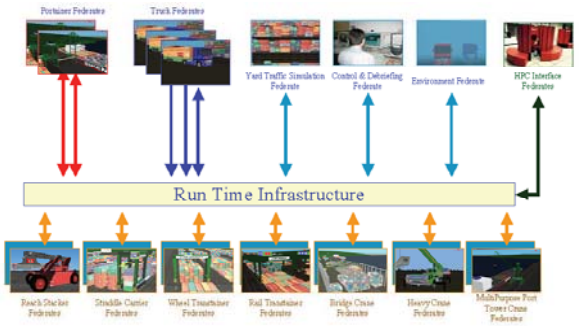

Figure 8: Run Time Infrastructure

OPERATIONAL MODES

At the beginning of each new training session, Cybersar simulator automatically generates the mission: the user can defines for every single operator which container has to be moved and the new position/destination to be reached.
The mission can be “multiple destinations”, in other words the trainee could be asked for moving the container from a yard allocation or a truck trailer and back again. Also, different levels of complexity can be selected, extra-move included, based on the necessities; to this end the simulator provides the user with “interference” in term of means and persons.
By using C++ language intelligent algorithms have been implemented in Cybersar simulator models and devoted to track other federates during communication drawback. Due to this fact dynamics of physics are introduced in each federate model. In fact, containers and trailers properties are shared among different users, on the contrary trucks, cranes and people properties are functions of each platform user.
The high level of complexity of such procedures can be understood if we consider that during the simulation several kind of vehicles are involved; due to this the containers handling must include a continuous reassignment of the different attributes.
The adopted solution for the federation architecture will allow that different vehicles will be able to interact; this approach will support not only training, but also policy definition, procedure design and infrastructure reengineering. These operation are very important in a intermodal systems where the overall efficiency depend upon synergy and harmony among equipment, people and planning. The policy redesign was already experienced by the researchers in port ship handling by using virtual simulation; in logistics

intermodal operation it is also possible to get great benefits from this analysis; in effect the proposed synthetic environment allows to proceed in the redesign of the handling devices themselves; for instance it will be possible to change the virtual cockpit of a crane and to identify the benefits in term of overall logistics performances and safety levels through an experimental campaign on the simulators. During development phase it will be critical to complete proper VV&A (Verification, Validation and Accreditation); in effect it is necessary to check logical consistency of conceptual models and proper identification of interoperability factors among federates as well as detailed validation of each single federate and overall federation. The validation of the federation in term of proper implementation and correct tuning of the factors and parameters represent another critical step. Considering these aspects the researchers proceed in this process by applying standard IEEE 1516.3 High Level Architecture Federation Development and Execution Process as well as fundamentals of 5000.61 directive related to VV&A (Verification, Validation and Accreditation); obviously it will be necessary to tailor properly the VV&A on this specific case; this approach will guarantee to complete effectively the verification and validation of the overall system; the researchers use extensively a network of experts in simulation applied to port logistics and DIPTEM laboratories in order to guarantee the success of this phase; vice-versa the availability of real logistics operators will provide full validation of the redesign capabilities of the system in relation to virtual function test of scenarios involving both HIL (Hardware in the Loop, for instance automation systems and sensors on the crane spreader) and MIL (Man in the Loop, for instance policies for exchanging container between different cranes).

Figure 9: Virtual Yard Operations

CONCLUSIONS

The presented study represents a step forward in the field of simulation, allowing such a technique to be promoted in new areas and providing the final users with a low cost interactive distributed HLA-based environment.
This makes possible to extend the application of simulation as training support system in new sectors, effectively facing interaction, cooperation, competition in a wide range of scenarios, taking into consideration a significant cost saving as well.
The testing experience allows to validate the system by extensive training campaign.
Currently the research is in its preliminary phase, objective definition and architecture design, however, thanks to previous experiences (INNOVARE, RESET, SITRANET) the integration test is expected for next October.

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