How to avoid checkmate

Virtual terminals support terminal operators in getting the most out of their TOS

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Requirements are escalating

Like in a chess match, terminal operators have to react to the moves of shipping lines and terminal equipment suppliers again and again. On the one hand, the next generation of container vessels – carrying some 18,000 TEU – is expected to arrive soon. On the other hand, new technologies are available that increase productivity at some point on the terminal. Using twin and tandem lift STS cranes can double moves per hour at the vessel, but can also build up new bottlenecks in other areas of the terminal. Therefore, current Terminal Operating Systems (TOS) are becoming more and more complex, and have to calculate some moves beforehand to receive the best result.

Nowadays huge terminals, especially Greenfield ones, are planned and optimized using simulation technology (see box) to guarantee optimal operation. But small and medium-sized terminals are much more affected by the changes described, as not only might they lose business to their competitors, but it's also rather a question of whether they thereby reach capacity and/or productivity limits. To avoid the checkmate, these terminals have to use new technologies like the virtual terminals described in this paper.

Simulation and emulation of container terminal operation

Container terminals may be supported by means of simulation and emulation during all phases of terminal planning, developing, start-up and operation.

Simulation ("The copy of a dynamic process in the form of a model, to get knowledge that can be applied to the real system") combines the information flow as well as the material flow within one model. It is used in the planning phase for defining the best layout, comparing various types of operation, and evaluates the quantity of equipment needed.

Emulation ("A model that accepts the same inputs and produces the same outputs as a given system" IEEE 610.3-1989) provides a virtual terminal that is connected to the Terminal Operating System (TOS) and behaves like the physical terminal. It may be used for testing as well as fine-tuning the TOS, training the control staff and replaying previous problematic situations.

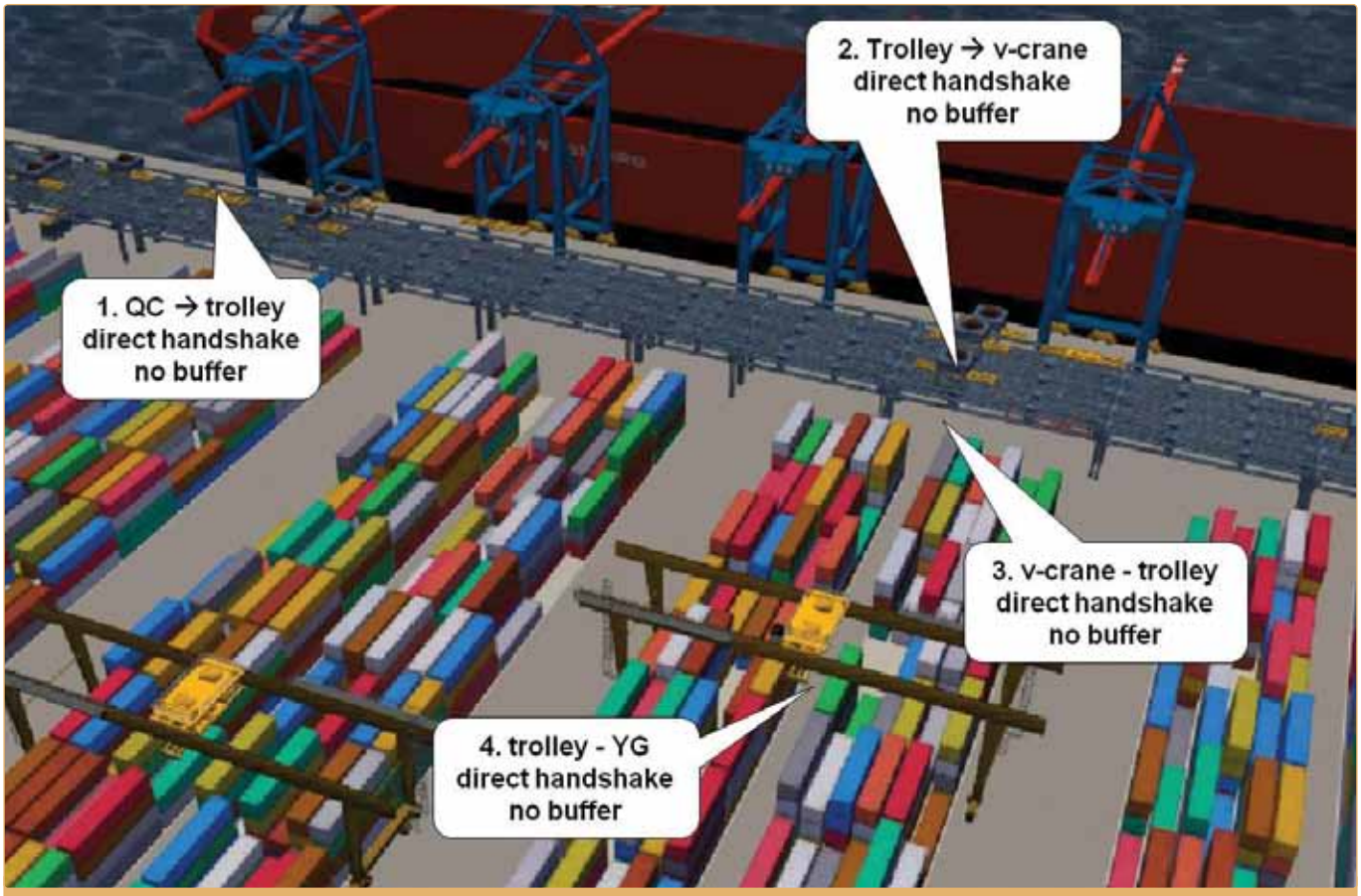

Figure 1. Some years ago, ZPMC developed the simple principle of horizontal transport technology.

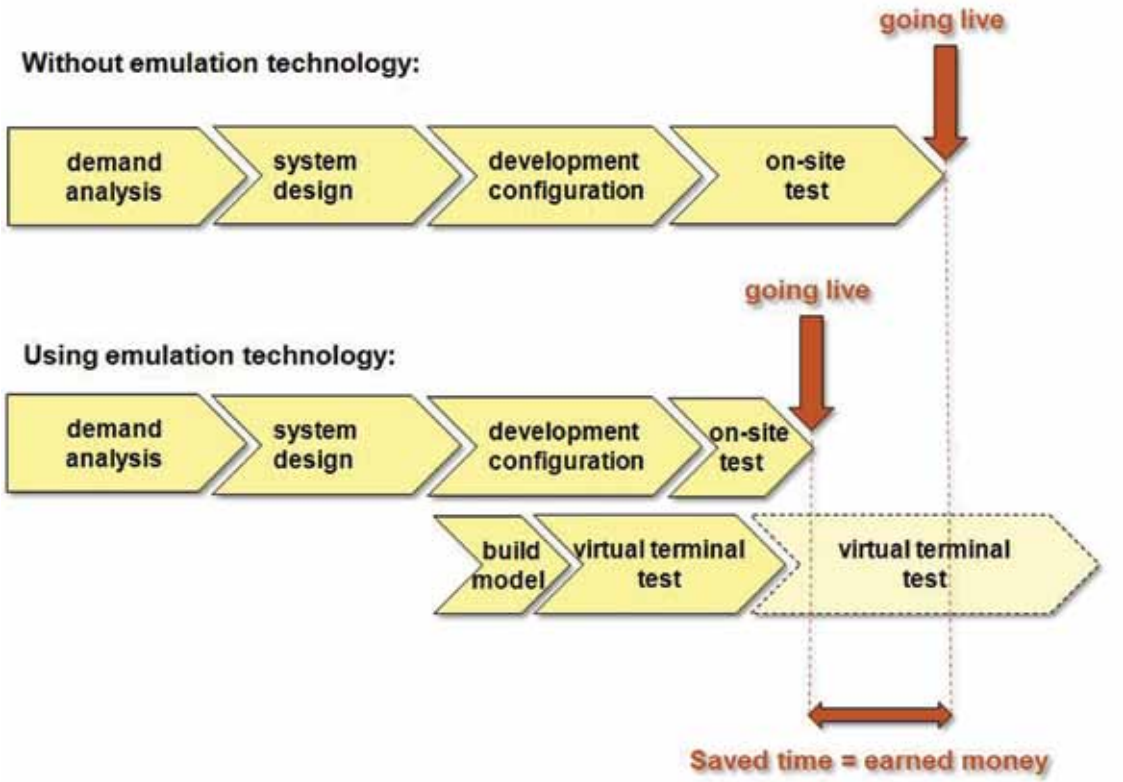

Figure 2. Where time is saved testing technology virtually before it goes live, money is saved too.

New strategies are demanded

To increase a terminal's productivity, often new technological approaches are used. In this way some years ago ZPMC, the Chinese market-leading supplier of STS cranes, developed a new horizontal transport technology. The straightforward basic idea of this concept is to divide the whole transport between the STS crane and the yard into small pieces. Each part of transport is done on only one axis:

- First transport is parallel to the quay, via platform using a supported carriageway
- Second transport is vertical from the rail to the ground by a moving crane
- Third transport is perpendicular to the quay using another platform on the ground.

All handshakes between the STS and the platform, the platform and the moving crane, the moving crane and the ground platform, as well as the ground platform to the yard stacking crane are to be handled directly without any buffer. Thus the equipment control of this technology has to ensure that all devices needed for the handshake have to be at the same place at the same time. This task seems not to be a problem for transport of a single container, but looking at a productivity of some 200 moves/h at a vessel shows the extreme complexity of this control task.

The same holds for the automation of container terminal operation. As the manned device at the terminal is equipped with highly sophisticated local intelligence (the brain of the driver), the automated one is not. Each decision about bypassing traffic congestions on the terminal and exception handling may be done by the driver directly. However, the central control of automated technology has to regard all possibilities, and has to

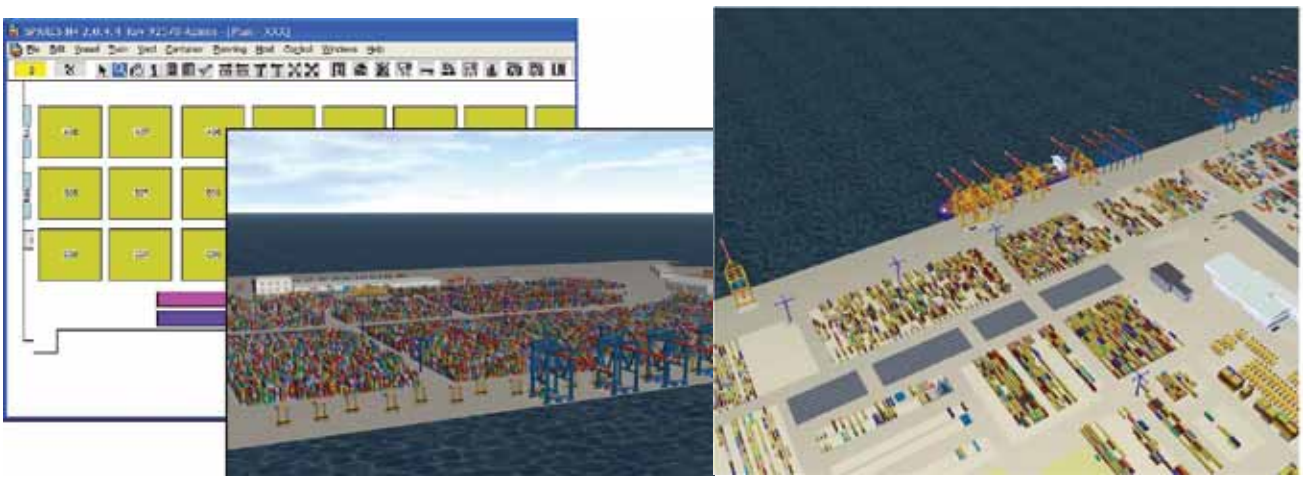

Figure 3. The layout defined in the TOS – such as Navis' SPARCS – is automatically converted into a virtual terminal.

Figure 4. A lot of training is required for operators to become Grandmasters of solving problems using virtual terminal software.

think for all single pieces of the equipment (e.g. some 70 AGV at the Container Terminal Altenwerder). The difference between artificial and human intelligence may be seen by the fact that chess computers are only just yet at the same level as the human Grandmasters after many years, and a lot of software developers trying to defeat them.

Virtual terminals

The basic idea of emulation technology (see box) that may support terminal operators is the provision of virtual terminals. These react to the TOS's commands as the physical ones do. A complete model including seaside operation, horizontal transport, stacking yard, gate operation and all equipment used at the terminal is built into the computer. The TOS, which is connected to the virtual terminal, does not know whether it controls the virtual or the physical one.

In this way, the TOS may be tested without disturbing the real operation. Neither operating costs nor wear of the equipment will occur during the test. Furthermore, environmental impacts such as noise and pollutant emissions will be avoided. Running these tests with the TOS guarantees the correct functionality, as well as it may be used to fine-tune the parameters controlling the strategies. The tests may be repeated as many times as needed (e.g. with different parameter settings) under exactly the same conditions – while the real-life weather conditions and workers' behavior will change for each test. Thus the changes in the results of these laboratory tests can be traced to the parameter changes.

Using the virtual terminal in the start-up phase of new terminals, or during the reorganization of existing terminals, will lead to less time needed for tests with the physical environment and thus will result in earlier start of operation, as shown in Figure 2.

(Semi-)automatic modeling

The tests with virtual terminals are only as good as the modeling of the terminal. Thus building a model has to be done in a very detailed manner and will take some amount of effort. Therefore easy to use modeling tools have to be designed. One module within this toolbox may be a graphical editor that allows the user to draw the layout of terminals. With the use of "copy and paste" as well as a package of predefined objects (e.g. a stacking block with various parameters describing the structure), the layout may be defined within a few hours.

To ensure compatibility with the physical terminal, the terminal description within the TOS, and the virtual terminal layout, an automatic converter has been developed. The yard block description from the TOS is used to define the blocks in the virtual terminal. The labeling and the numeration of the stacks, as well as their rows, slots and levels may be taken directly from the TOS. The same holds for the equipment in use and their technical data (as far as it is available in the TOS). This semi-automatic method will speed up building virtual terminals, and thus may smooth the way for small and medium-sized terminals using this technology in an economic way.

Do it yourself

Another important method of using a virtual terminal for optimizing operations is to enable the terminal operator himself to update it according to changes in the layout, the equipment (quantity as well as technical data), and so on. This may be done in the same manner as terminal operators are already familiar with from their TOS configuration.

The TOS typically is developed by the TOS suppliers such as NAVIS, TotalSoftBank, CyberLogitec, Jade, RBS, Tideworks, and

others. They deliver the entire software solution (as a standard product), and customize it regarding the individual demands of the terminal. They train the control staff of the terminal to use the software, as well as to configure it to upcoming new demands. Typically, terminal staff are in the position to do all changes needed in the day-to-day operation. From time to time, it may be a good idea to invite a TOS expert to have a look at the system and to check whether it is working in an optimal way. If there are huge reorganizations at a terminal, often these specialists are called to help the control staff to start up the reconfiguration and then leave after a short time.

Today, this is also possible with simulation and emulation technology. The terminal operator purchases the virtual terminal software (only few operators develop their own systems). The supplier will build the first model, including the TOS interface. The layout modeling may be done within the first training session, as well as the definition of the equipment. At the end of the installation and training the control staff will be able to use the virtual terminal for testing purposes. Furthermore, they will be able to change layout parameters, and modify the number and technical data of equipment. Scenarios may be defined by logging actual shift data and may be enhanced by the user. Very experienced users may also define brand new terminals as far as they are controlled by the same TOS. For special challenges, the terminal operator may ask the supplier for support during the start-up phase of new projects.

Thus the usage of the virtual terminal software may be compared with varieties of chess: beginners will start without time limits, at some level they will start to play blitz chess, and Grandmasters play simultaneous chess.

Become a Grandmaster

To become such a Grandmaster, a lot of training is required. The virtual terminal allows the control staff to train in controlling their terminal using their TOS, using historical data from bygone shifts. Problematic situations at the terminal may be replayed and the staff may learn how to solve the situation better next time.

Learning from shipping lines that use vessel simulators to train their shipmasters, terminal operators may use the virtual terminal as a training centre. Predefined scenarios (for example, captured from previous operations) are to be controlled by the trainees. As mentioned before, the environment is the same for each match as well as for each participant. Thus the trainee is able to recognize the changes in the output directly as a result of his own input variation, which is the best way of learning, from a psychological point of view. Championships may even be organized to find the best control expert of the training session.

Conclusion

Virtual terminals enable terminal operators to optimize the parameter settings of their TOS, as well as training their control staff to find the best moves to the demands of day-to-day operation. As IT technology has improved, small and medium-sized terminals are in the position to use virtual terminals in an economical way, and thus survive in competition and win the match.

ABOUT THE AUTHOR AND COMPANY

Prof. Dr.-Ing. Holger Schuett has been working in the field of container terminal optimization for more than 20 years. He is CEO of ISL Applications GmbH and since 2003 has been Head of the Competence Center of Optimization and Simulation within the Institute of Shipping Economics and Logistics (ISL). Furthermore he took up a professorship at the University of Applied Science in Bremerhaven in 2010. Before Holger worked as a project manager at HHLA/ Hamburg, his most famous project had been the simulation based consultancy of the new fully automated container terminal Hamburg Altenwerder.

ISL Applications GmbH has been founded in September 2010. It will market and customise ISL's simulation and emulation products and will offer training, consultancy services and maintenance to the clients. ISL has more than twenty years experience in the market of supporting container terminals with means of simulation and emulation. The product family CHESSCON (formerly known as SCUSY, CAPS, ViTO) is used worldwide in all five continents by terminal operators as well as planning organizations.

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