Collaboration in design and engineering

Herbert Koelman, SARC, The Netherlands explains how Numeriek Centrum Groningen (NCG), SARC and Conoship have joined forces to be able to create a better CAD/CAE software system

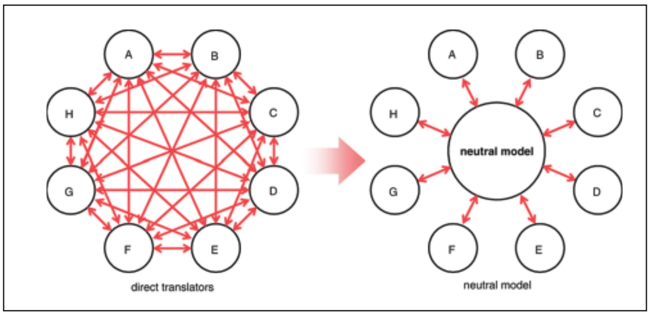

Figure 1: A neutral model is assumed to save on interfaces, [2]

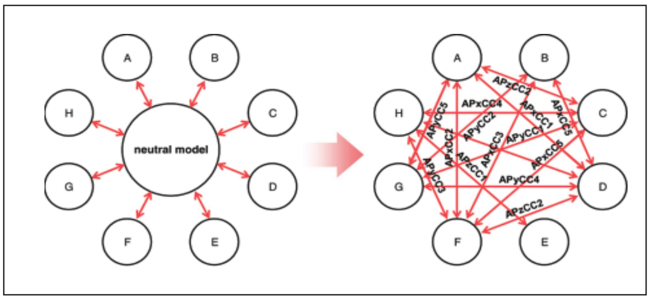

Figure 2: From theory (left) to practice (right), [2]

In the early days of the application of computers for the design and engineering of ships, inter-programme communication was somewhat cumbersome, however, there was a spirit of optimism that an interconnected world was about to emerge.

The first step in that process was the embracing of the concept of a 'neutral model'; one common repository where all data resides, and to where all applications are linked. Figure 1 demonstrates that without such a model, and with eight applications, 56 bilateral interfaces must be available, in sharp contrast to the only eight interfaces with the common model.

It was a fine idea at the time, which formed the core of quite some developments; just for The Netherlands, there are five. Also international neutral model standards emerged, such as initial graphic exchange specification (IGES) and Standard for the Exchange of Product Model Data (STEP). Decades on; a survey[1] on the use data exchange standards shows that those neutral model standards are only applied in some 35% of the cases. Without commenting, we can conclude that the neutral model did not emerge fully.

An overview paper[2], reflects on the potential of the neutral model paradigm, and concludes:

- The assumption that a neutral model can be postulated, be made available, and be used by all applications does not hold.
- The meaning of the applied concepts – the semantics – should be agreed on the forehand. For this reason the contributing parties should know each other.
- Multiple representations for the same entities might be applied – this is called 'representation variation' – and brings the requirement of conversion between representations. Some representation can unambiguously be converted (e.g. straight line through two points → vector representation), others cannot (e.g. triangulated surface → NURBS). An experiment with three conversion examples leads to the conclusion that "In all three cases, significant differences between the files were found: some entities disappeared, others appeared, and again others were changed". The paper concludes that "The neutral model does not really exist"; instead there are multiple converters for the variety of representations, as depicted in figure 2.

With this background knowledge three Dutch partners undertook the endeavour to adapt their tools and products in order to create a CAD/CAE system, composed of already available components. The aim was a single virtual ship design and engineering systems. The partners involved are NCG – manufacturer of the NUPAS-CADMATIC software for CAE, Conoship – a ship design office, and SARC – manufacturer of the PIAS Computer Aided Ship Design software. Having learned the lessons that a centralised top-down approach requires quite some effort and does not guarantee success, a more grass-roots kind of approach was adopted:

1. The dictionary is not predefined, but grows on demand. Just like a dictionary of a natural language.
2. The applications communicate over the network, by the TCP/IP protocol.
3. As 'language' XML was adopted, for the reasons that it is easy to understand by a human, it is easy to consume by a computer and it offers some semantic support.
4. A central repository – a common database or other form of data storage – is initially not used.
5. Not only is data shared, but applications can also send requests to others – and receive a proper reply.

The last item may require some elucidation. Up to now most approaches have been data-centric, so communications were limited to the 'product model' of the ship design. However, the disadvantage is that each participant – application – should replicate the entire product model, in order to be processed.

Given the pitfall of the 'representation variation', as discussed before, such a

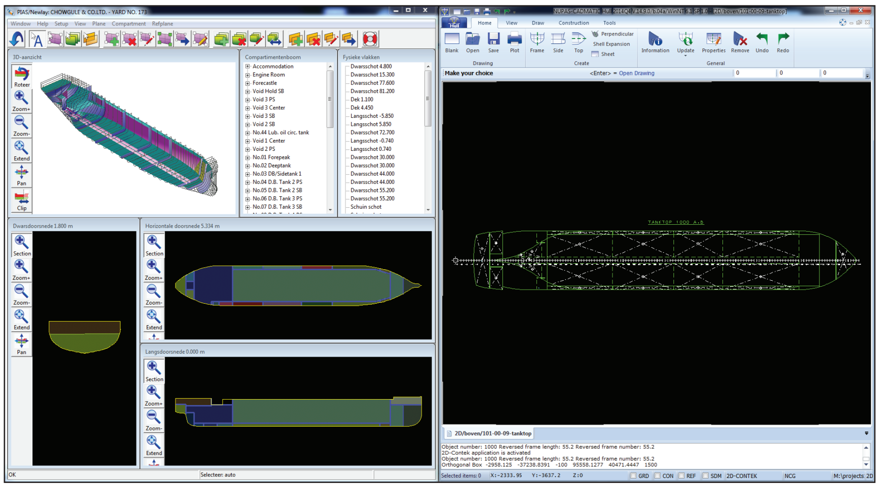

Figure 3: Left the PIAS modeller for internal shape, right the generated tank plan in NUPAS-CADMATIC

replication will in any case be laborious, and might even fail. However, if one application is capable of simply asking for a derived result, life becomes much easier. For example:

- If application A manages the shape data of hull form and compartments, then application B can request the shapes of intersections from A at different levels. In this case a general arrangement plan application can quickly be set up in a general CAD system without the need for the CAD system to maintain a full geometric model.
- Commonly, in a tank plan a list of tanks and their capacities and centres of gravity is included. Again, in order to save the tank plan application from the burden of volumetric computations, those parameters can be requested from a connected application which already has this capability, for example the tank sounding module of the hydrostatic package. These requested capacities are not stored in any way, neither local, nor central. They are simply printed in the tank plan, and never used again. The advantage is that we don't need to worry about the validity of stored data, if the tank plan is updated the capacities are simply requested again and recomputed.
- If an application has specified capabilities, say to enlist all compartments and bulkheads that are encountered by a pipe, then the other applications can use this capability without the need to replicate it.

Such a request-reply way of operation was recently also proposed in [3].

NCG, Conoship and SARC have implemented a pilot for such a system, which is about to be finalised for evaluation by now. Figure 3 shows a screenshot. Essentially, in this way a single virtual CAD/CAE system has been created, which consists of collaborating, but otherwise distinct tools. The pilot covers:

- Hull form design
- Internal shape design and manipulation: bulkheads, decks and compartments
- Structural arrangement topology
- Generation of general arrangement plan and tank arrangement plan.

The hull form details are available to all three systems in a reply/request fashion. The internal shape and structural topology (which are essentially the same) is visible in each of the three systems, while a modification in one system is immediately synchronised with the others. In this way the consistency of the ship design is ensured, in, for example, the following scenarios:

- The internal geometry is modelled in NUPAS, and immediately available in the other software. With the Conoship CAD system a tank plan is generated, including a tank volume table, which is generated by reply/requests to PIAS. After each geometry modification the tank plan is re-generated, so the volume table is always up-to-date
- The internal geometry is modelled in PIAS, and applied for the preliminary intact stability and probabilistic damage stability calculations. Based on this geometry, in NUPAS all construction is modelled, a process in which for practical reasons some geometry may be adjusted. Afterwards, the modified internal geometry is immediately available in PIAS for final intact and damage stability assessments
- With the internal geometry modeller open on the left monitor, and Conoship's CAD application – which includes sizing verification tools on the right - the system works as a whole, with the effect of shape modifications on the left monitor directly visible on the right.

Although it is still too early to report on experiences in the harsh ship design practice, the following conclusions emerge:

- The system works as anticipated. The smooth data sharing reduces ship design times, ensures model consistency and, as a result, reduced the failure probability
- The ratio between implementation effort and gained results is remarkably low
- No performance degradation due to network traffic was experienced
- The system relies on instant messages from applications to each other. It will be obvious that all applications should be switched on, and attached to the current design project, in order for these messages to be processed correctly.

These findings have motivated the partners to continue with these developments. In particular, the inclusion of piping is the subject of current investigations, because it plays a vital role in design (at damage stability) as well as engineering. *NA*

References

[1] VIJAY SRINIVASAN, 2008. Standardizing the specification, verification, and exchange of product geometry: Research, status and trends. *Comput. Aided Des. 40(7), 738-749.*

[2] WIM GIELINGH, 2008. An assessment of the current state of product data technologies. *Comput. Aided Des. 40(7), 750-759.*

[3] CHRISTOPH HOFFMANN, VADIM SHAPIRO, and VIJAY SRINIVASAN, 2014. Geometric interoperability via queries. *Comput. Aided Des. 46(1), 148-159.*