On the Representation of the Simulation Event Set

In a recent paper Ulrich [3] reported on a new method, i.e. the 'converging lists' data structure, for maintaining the event set for discrete simulations requiring large numbers of events. We find it necessary to dispute two specific claims made in this paper: (1) superiority over the TL structure [1], and (2) superiority over the indexed list method [4] as it concerns event scheduling.

As to (1), Ulrich deduces from our paper [1], that "at least 100 machine instructions are required to schedule the typical event" and then states "With the algorithm described here, fewer than 30 instructions are required." This statement is to be supported by performance evaluations done by Phillips and Tellier [2]. We have two main observations to make. One, the performance evaluation in [2] measures the time to schedule an event, whereas both [1] and [4] measure hold time. Two, the results reported in [2] are obtained with an index table of size 512, whereas [1] and [4] use a table size of 30! Seemingly less than a fair comparison. In terms of algorithm analysis, none is given. Actually, the algorithm described in [3] has an $O(n)$ worst case complexity compared with an $O(\sqrt{n})$ worst case complexity in [1]. Furthermore, it should be observed that Ulrich, Phillips, and Tellier compare an implementation done in Pascal with an implementation done in BLISS, a system implementation language.

As to claim (2), we fail to find any conceptual difference between Ulrich's approach and the indexed list of [4]. On the implementation level the main differences seem to be:

(a) Ulrich postpones dynamic incorporation of events in the overflow list into the indexed lists until the events in half the table have been executed.

(b) Ulrich uses the standard compiler optimization technique of loop unrolling and replaces the modulo computation by a shift-and-mask operation.

(c) Ulrich uses a singly linked list and an additional pointer to remember the last node visited in lieu of a doubly linked list.

Concerning point (a) above, Ulrich claims that by postponing the problem it will more or less go away since "Usually, there should be none or only a few" (nodes in the overflow list). How many events will be in the overflow list is strictly a function of the distribution in the event set and the table size and again the worst case is of $O(n)$ in [3]. In addition we note that by postponing the reorganization, on the average 25 percent of the table will not be utilized and that just before the special events $rh1$ and $th2$ are executed half the table will not be utilized.

Finally we would like to remark on the nonchalant use of large tables and the tacit assumption that in most simulations events occur only at integer multiples of a fixed time interval, which seems to permeate much of the discussion (e.g. "For example, the maximum length of the horizontal list can be forced to time units of 8, 4, 2, or 1. This means that the average scan for scheduling a new imminent event cannot encounter more than $4, 2, 1$, or $1/2$ [sic] of the already scheduled items.") As an example, consider the bimodal distribution in [4] with 500 events in the event set. A snapshot of the event set showed a range of event times between .5 and 10.0 with 4 percent of that range containing all event times. We estimate that Ulrich's algorithm would need a table of size 2000 with approximately 1900 entries representing empty lists to give a performance comparable to [4], and it has to be remembered that it does take a comparison to find out that an entry in the table represents an empty list.

In summary, although Ulrich's paper contains many worthwhile points concerning the implementation of the event set, the two specific claims of superiority over existing methods do not hold up in light of the $O(n)$ worst case complexity in [3], an absence of a reasonable performance comparison, and the lack of a clear statement as to what the improvements over existing methods are (beyond minor implementations improvements). It might be the case that Ulrich's method is indeed better than the TL algorithm in specific circumstances. But we believe that the one claiming superiority over an existing method should be the one to prove it—either through analysis or performance evaluation. If a performance evaluation is done it should be a fair one (as was the case for the comparisons with earlier work in [1]); that is, both methods should be implemented on the same machine using the same language, and the same optimization techniques should be employed.

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Author's Response:

Franta and Maly are ignoring solid evidence provided in the paper by Phillips and Tellier. Comparing Figures 12 and 13 in that paper with Figure 5 in theirs clearly demonstrates that the Phillips/Tellier implementation of the converging lists algorithm is typically three to four times faster than the reported imple-
The consideration of extreme cases of one particular unlikely event distribution.
(5) A good portion of the speed of the converging lists algorithm is due to using a time-wheel table of length $2^p$. This fact is vital and permits use of a shift-and-mask sequence rather than a modulo operation to enter the table. The attempt to dismiss this as a minor implementation detail is questionable.
(6) Finally and most importantly: A fundamental feature and basic advantage of the converging lists algorithm is the distinction between simultaneous and nonsimultaneous events. This distinction is absent within the TL and other predecessor algorithms. Franta and Maly must be aware of this difference, but appear to be unable to appreciate its conceptual and practical importance.

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On Encoding of Line Numbers

In his article [1] Paul Klint gives a method to encode the line numbers of a high level language program in unused instructions or unused instruction fields in the translated machine code. This technique is fine when using abstract machine code but raises a problem when using real machine code.

When designing new computer models the manufacturer often makes them compatible with earlier models by using the same instruction codes and cramming new instructions into hitherto unused fields. This means that compilers using Klint’s technique will not always be portable from one machine in a series to another even if all other software is. And the translated programs could start showing side effects due to the execution of instructions which had been intended as no-ops.

One could solve the latter problem by retranslating all programs using the changed compilers when shifting to a new computer (even though the new model is compatible with the old). It would mean some work, however, and one cannot always be sure of having the source program available.

Another solution would be to have computer manufacturers promise to leave certain dummy fields “untouched” in future models, thereby dedicating them to line number-bookkeeping and similar purposes.

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Author’s Response:

Jakob Nielsen correctly remarks that there is a certain danger involved in employing unused instruction fields for maintaining the line number administration. There is, however, a difference between the use of defined instructions with zero effect (as in the examples I gave) and the use of undefined instruction fields. The former can be used safely, while the latter may have disadvantages as described by Nielsen.

His proposal to leave some unused fields untouched in all future models of a certain computer is unrealistic and does not solve the problem in a fundamental way. In fact, techniques as presented in my paper are a subterfuge and reflect the enormous gap between programming languages and current computer architectures. A better solution than the one proposed by Nielsen would be to integrate line numbers completely (and of course other entities related to the source text level) within the architecture of future computers.

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