Theoretical Computer Science 52 (1987) 341–342
North-Holland

NOTE

A NOTE ON: 'DEQUE AUTOMATA AND A SUBFAMILY OF CONTEXT-SENSITIVE LANGUAGES WHICH CONTAINS ALL SEMILINEAR BOUNDED LANGUAGES' (BY K. AYERS)

Theoretical Computer Science 40(2, 3) (1985) 163–174

Franz J. BRANDENBURG

Lehrstuhl für Informatik, Universität Passau, 8390 Passau, Fed. Rep. Germany

Communicated by M. Nivat
Received February 1987

The topic of Ayer's paper are nondeterministic automata with one output restricted deque as worktape and operating in quasi-realtime (see [2, 5]). Clearly, in its mode of operation, an output restricted deque lies between a queue and a multihead Turing tape. Hence, the family $\mathscr{D}$ of languages accepted by the machines under consideration lies between Post(n), the family of languages accepted in real time by nondeterministic machines with one queue or Post tape (see [3]), and NTIME(n), the family of languages accepted in real time or in linear time by multitape Turing machines (see [2]).

The latter insight improves [1, Theorem 2.1], and the further relation together with results from [6] show that Theorem 3.6 in Ayer's paper is *false*: languages in the class Post(n) have an undecidable emptiness problem. For a proof, observe that deterministic machines with a queue as a worktape can simulate a Turing machine in quadratic time.

At last let me state an open problem in the field of Ayer's paper. See also [4]. Consider the families of languages accepted in real time (or in linear time) by nondeterministic machines whose worktape is a queue, or an output restricted deque, or a deque, or a finite number of Turing tapes respectively. Is this a strict hierarchy of families of languages?

References

[1] K. Ayers, Deque automata and a subfamily of context-sensitive languages which contains all semilinar bounded languages, *Theoret. Comput. Sci.* **40** (1985) 163–174.

[2] R.V. Book and S.A. Greibach, Quasi-realtime languages, *Math. Systems Theory* **4** (1970) 97-111.
[3] F.J. Brandenburg, Multiple equality sets and Post machines, *J. Comput. System Sci.* **21** (1980) 292-316.
[4] F.J. Brandenburg, A, Brandstädt, and K.W. Wagner, Uniform simulations of nondeterministic real time multitape Turing machines, *Math. Systems Theory* (1987) (to appear).
[5] D.E. Knuth, *The Art of Computer Programming, Vol. 1* (Addison Wesley, Reading, MA, 1973).
[6] Z. Manna, *Mathematical Theory of Computation* (McGraw-Hill, New York, 1974).