

4 Modelling Issues

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- ▶ Implementing and testing on representative inputs
 - ▶ How do you choose your inputs?
 - ▶ May be very time-consuming.
 - ▶ Very reliable results if done correctly.
 - ▶ Results only hold for a specific machine and for a specific set of inputs.

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How do you measure?

- ▶ Implementing and testing on representative inputs
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 - ▶ May be very time-consuming.
 - ▶ Very reliable results if done correctly.
 - ▶ Results only hold for a specific machine and for a specific set of inputs.
- ▶ Theoretical analysis in a specific **model of computation**.
 - ▶ Gives **asymptotic bounds** like “this algorithm always runs in time $\mathcal{O}(n^2)$ ”.
 - ▶ Typically focuses on the **worst case**.
 - ▶ Can give lower bounds like “any comparison-based sorting algorithm needs at least $\Omega(n \log n)$ comparisons in the worst case”.

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Example 1

Suppose n numbers from the interval $\{1, \dots, N\}$ have to be sorted. In this case we usually say that the input length is n instead of e.g. $n \log N$, which would be the number of bits required to encode the input.

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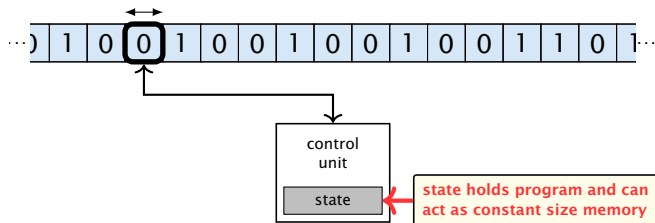
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Version 2. is often easier, but focusing on one type of operation makes it more difficult to obtain meaningful results.

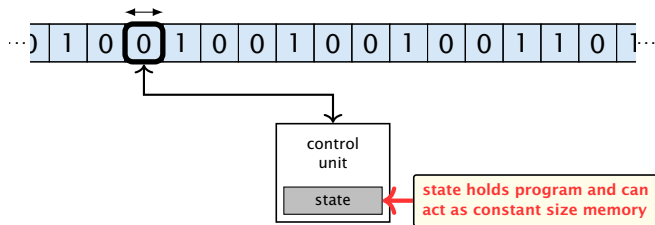
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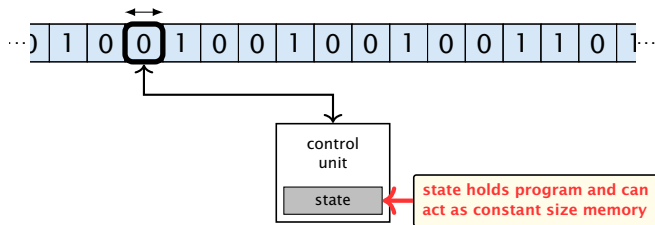
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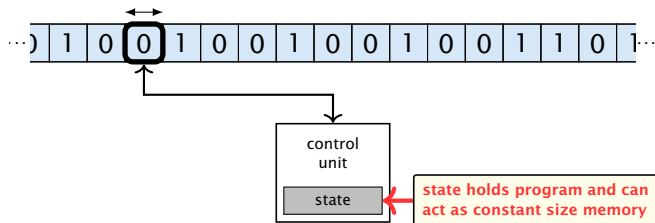
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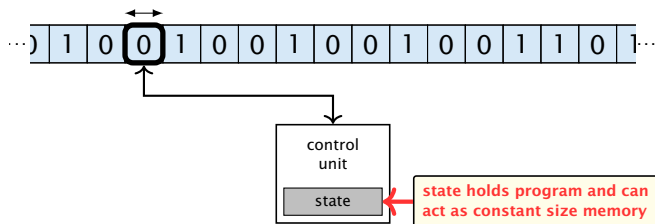
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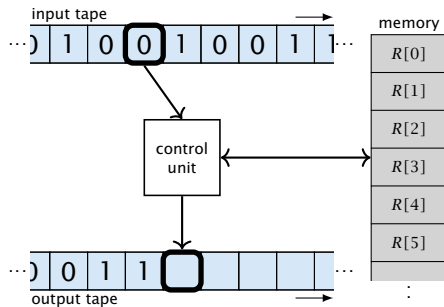
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⇒ **Not a good model for developing efficient algorithms.**



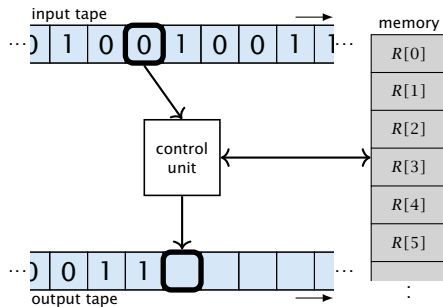
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- ▶ Input tape and output tape (sequences of zeros and ones; unbounded length).



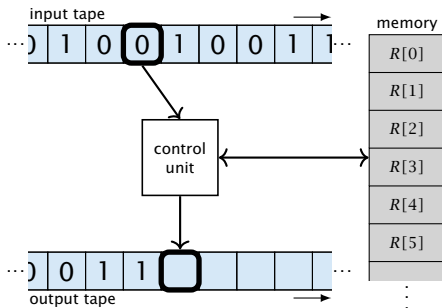
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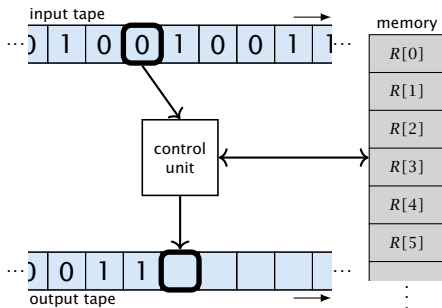
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 - ▶ $R[i] := R[j] + R[k];$
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Bounded word RAM model: cost is uniform but the largest value stored in a register may not exceed 2^w , where usually $w = \log_2 n$.

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Algorithm 1 RepeatedSquaring(n)

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more general: probability measure μ

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The algorithm may use random bits. Expected running time (over all possible choices of random bits) for a fixed input x . Then take the worst-case over all x with $|x| = n$.