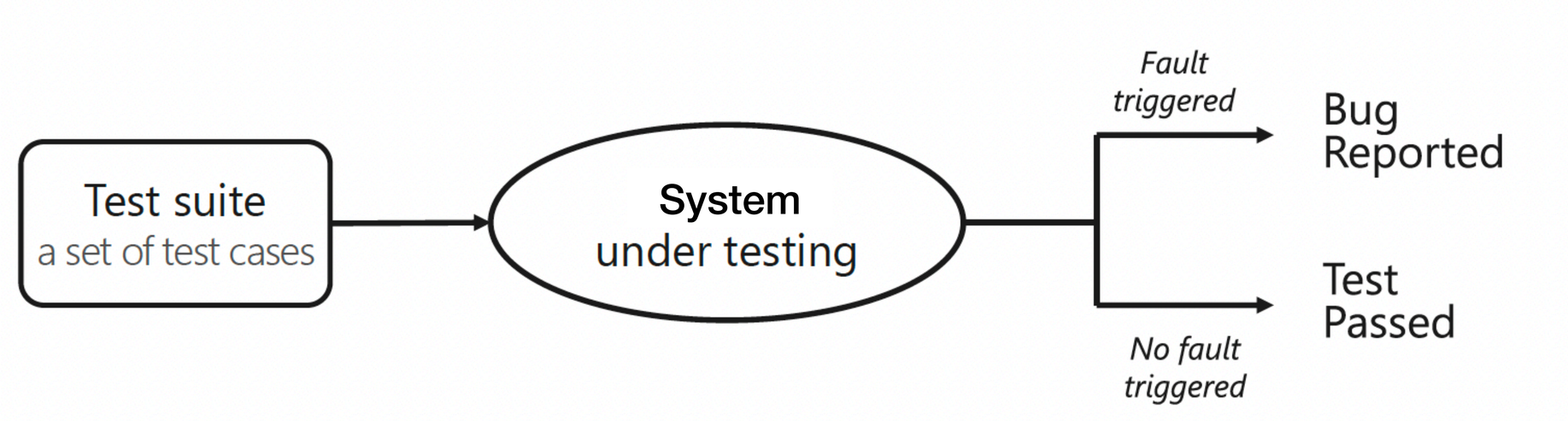
CAmpactor: A Novel and Effective Local Search Algorithm for Optimizing Pairwise Covering Arrays

Qiyuan Zhao, Chuan Luo, Shaowei Cai, Wei Wu, Jinkun Lin, Hongyu Zhang, Chunming Hu

Image credit: https://en.wikipedia.org/wiki/Compactor

For ESEC/FSE 2023

Combinatorial Interaction Testing



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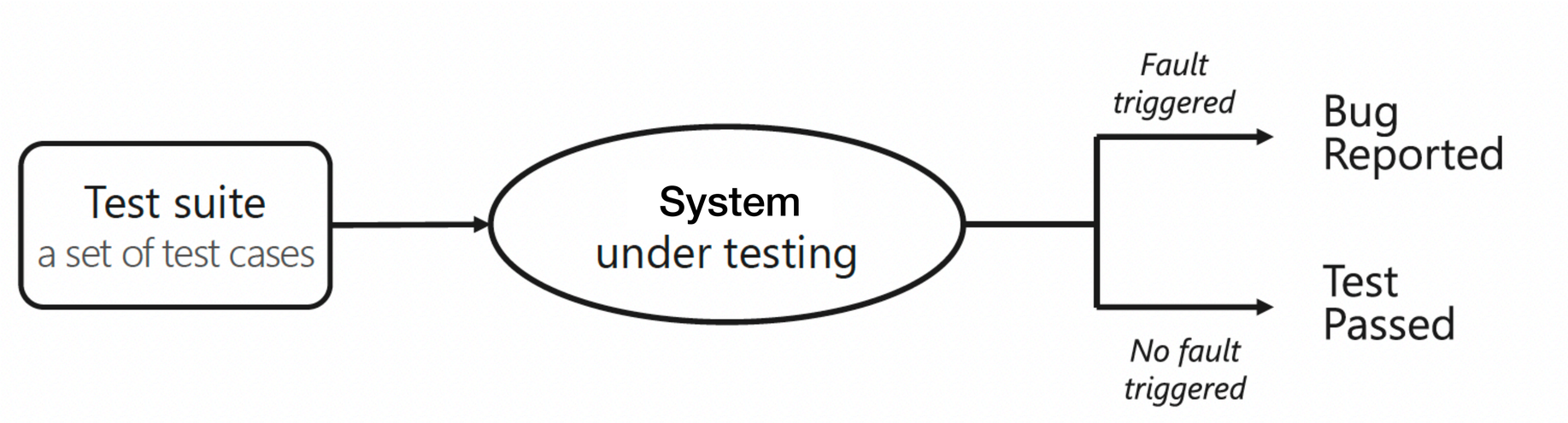

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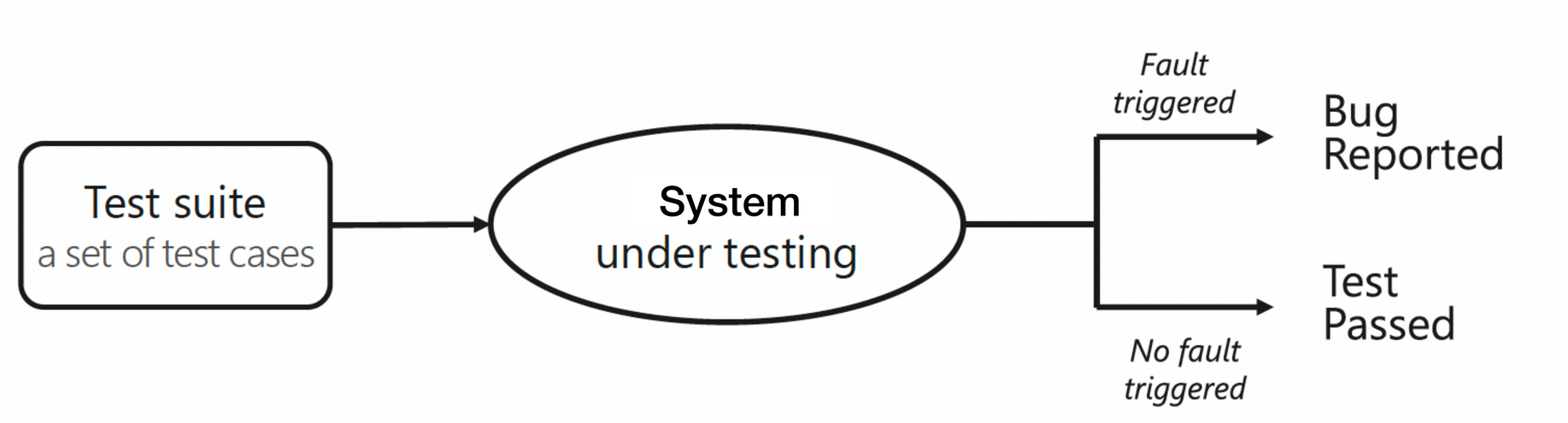

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- **Test case***:* configuration of options

Combinatorial Interaction Testing (cont'd)

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  - **Initialization phase**: constructing PCA quickly
  - **Optimization phase**: reducing the size of PCA (e.g., by **local search**)

PCA Optimization By Local Search

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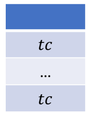
Initialization



Initial PCA
size=N

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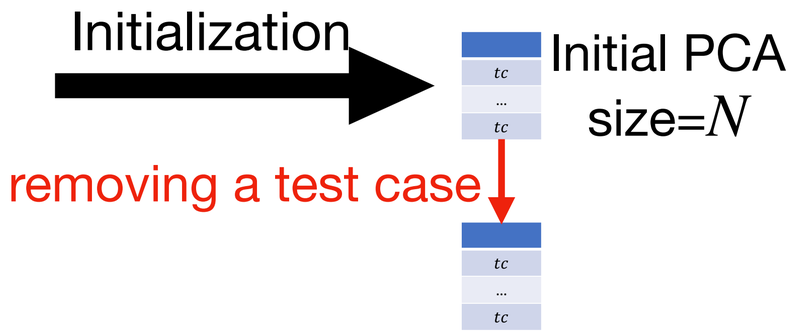

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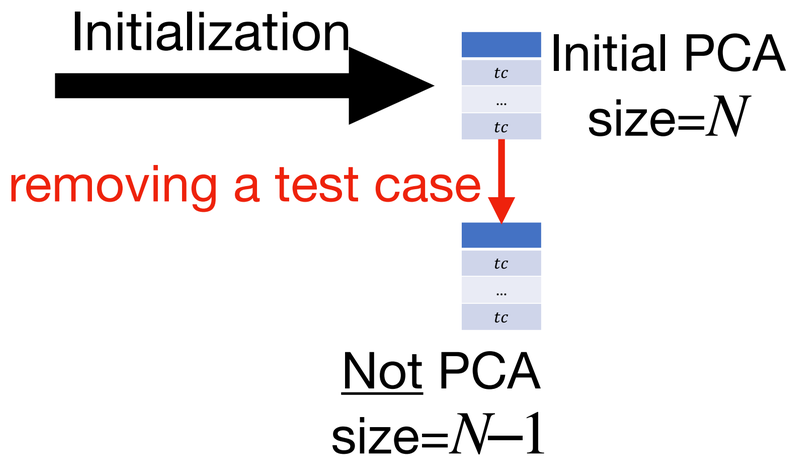

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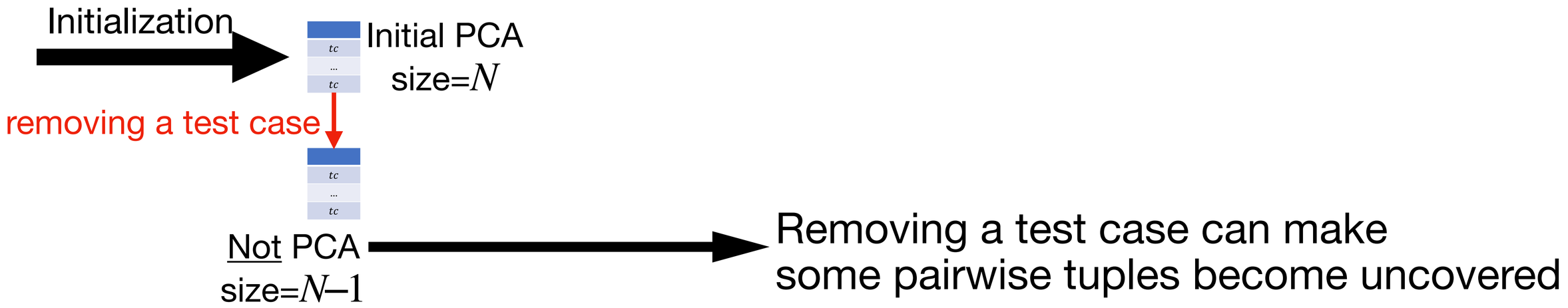

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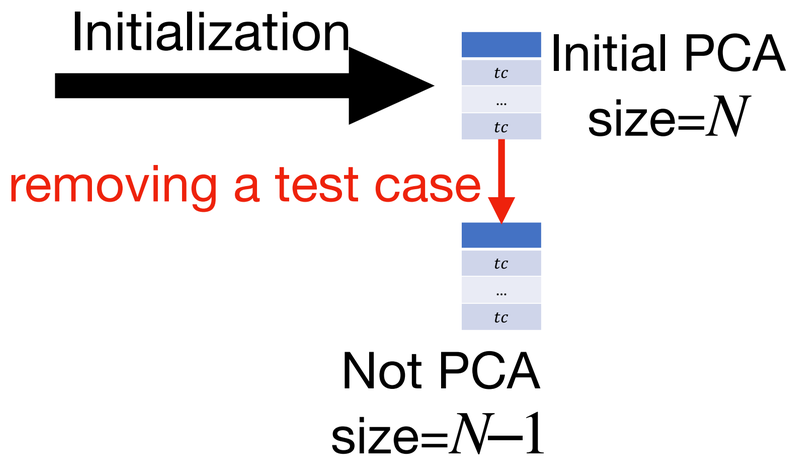

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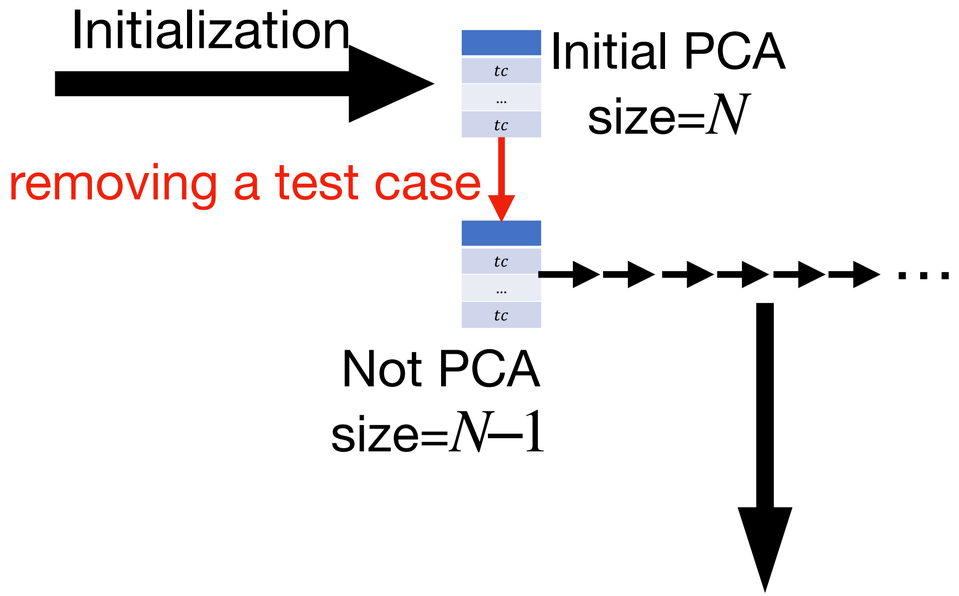

Local search steps: modifying existing test cases in the set to make them cover the “lost” valid pairwise tuples

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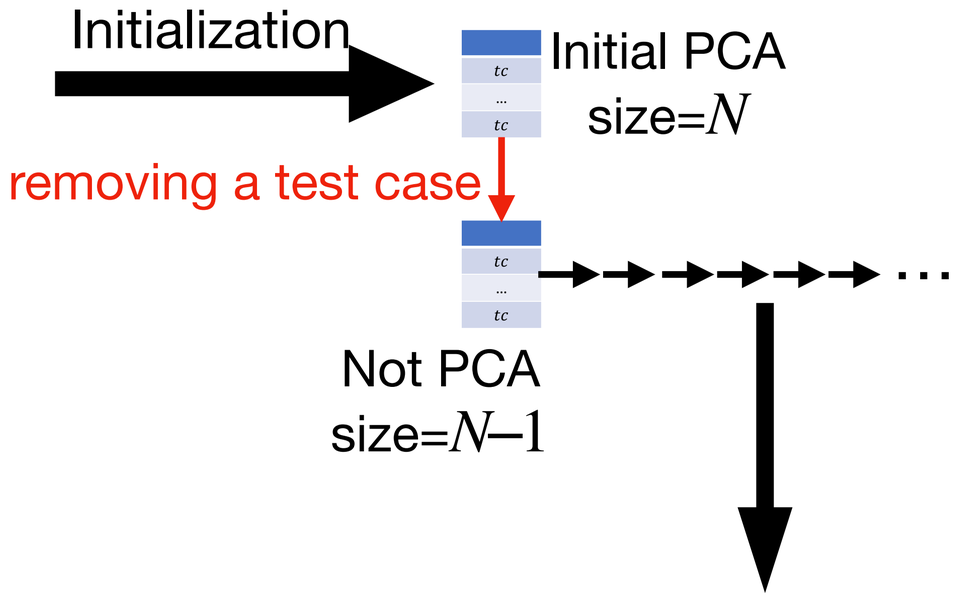

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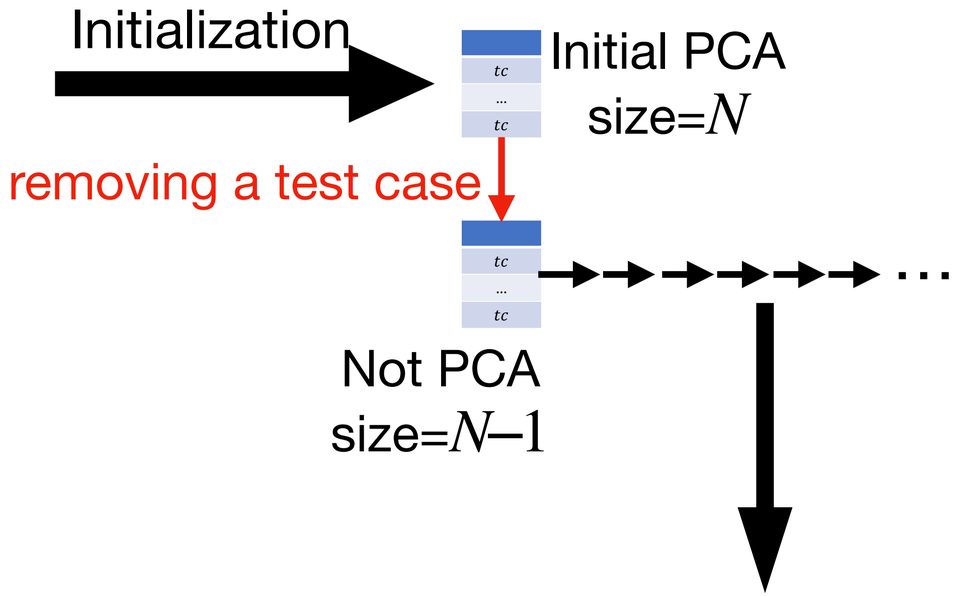

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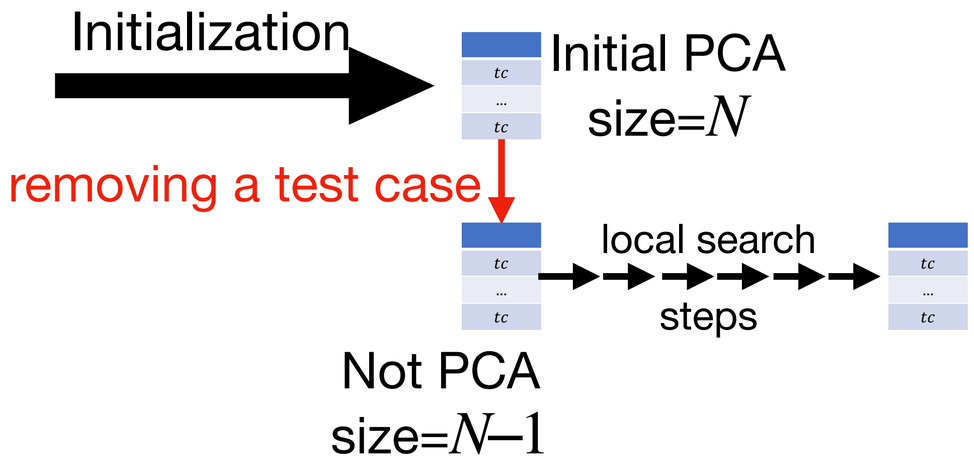

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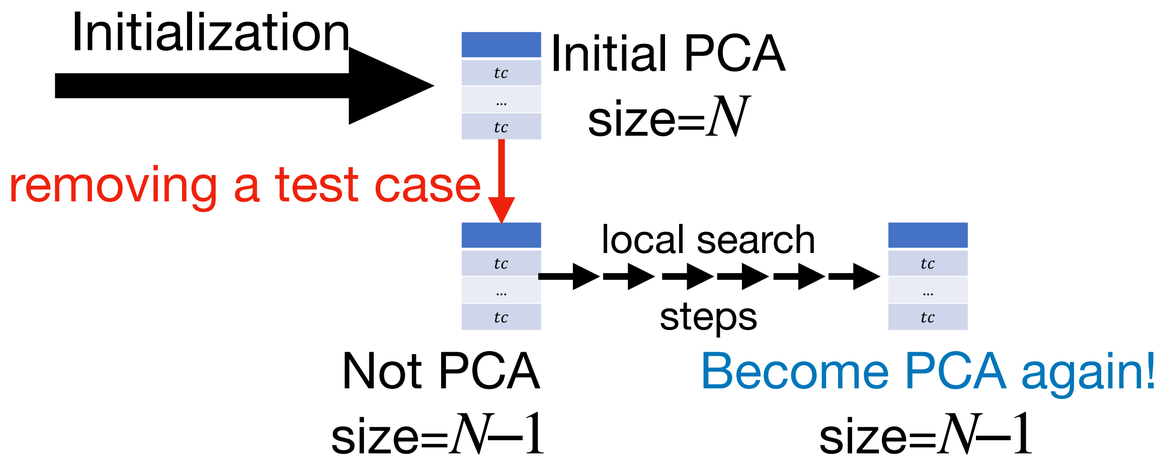

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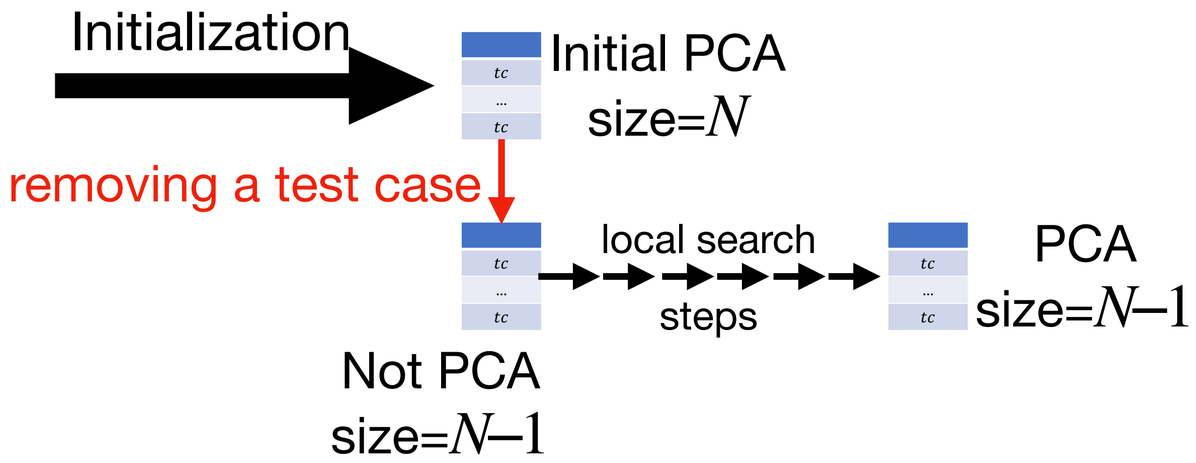

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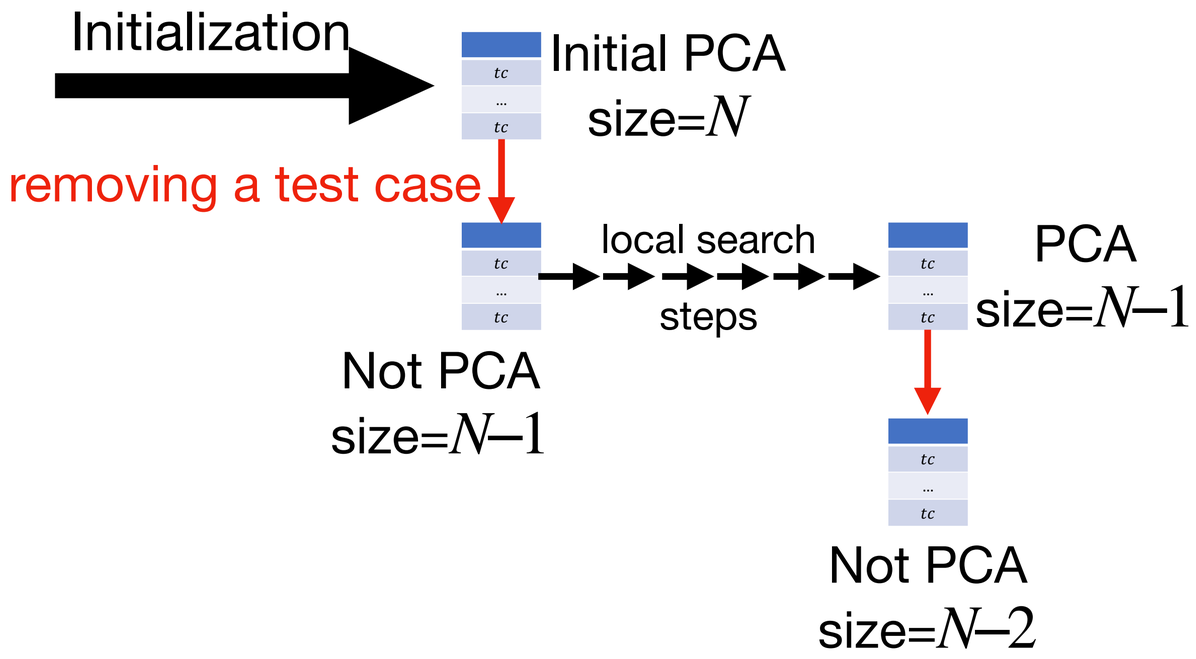

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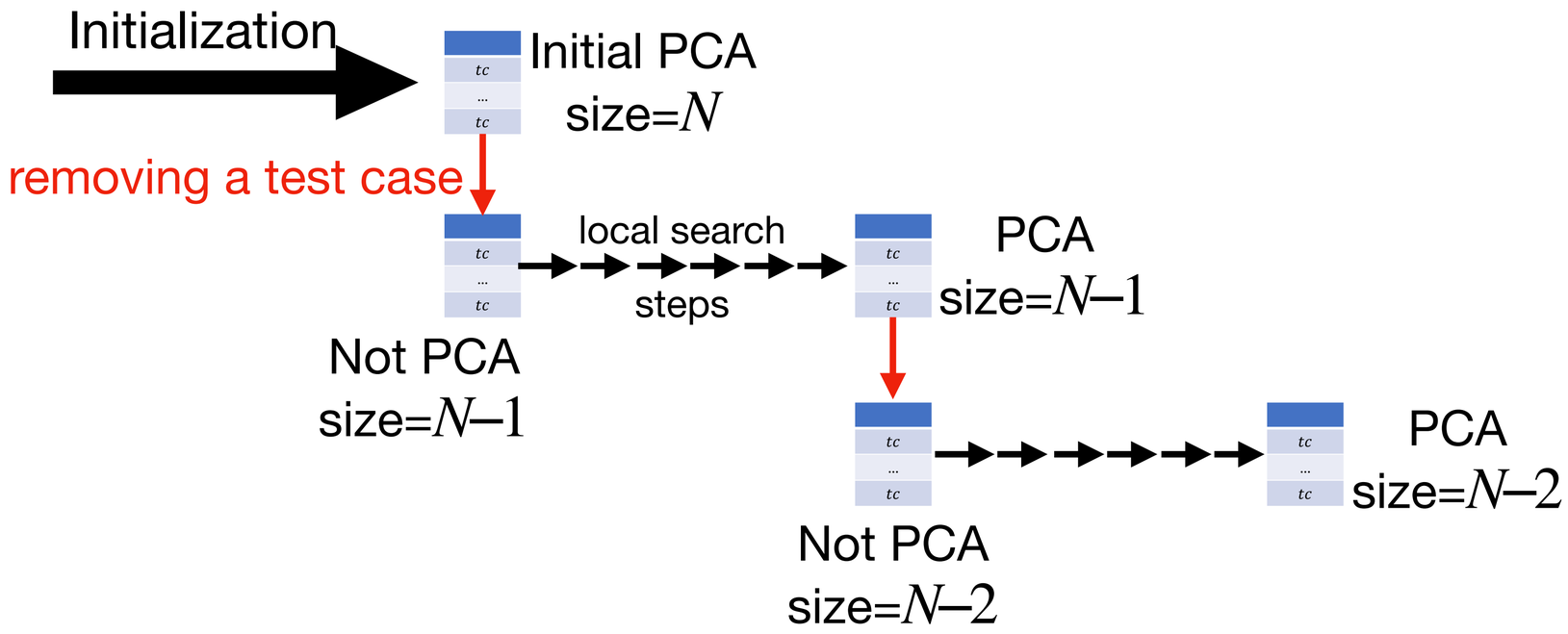

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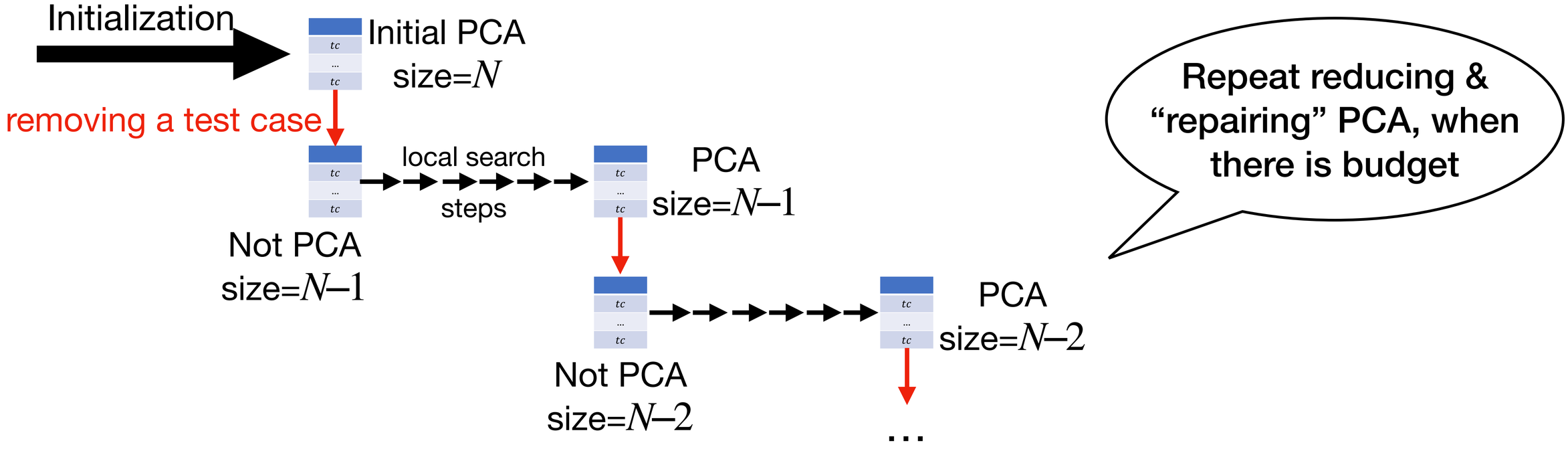

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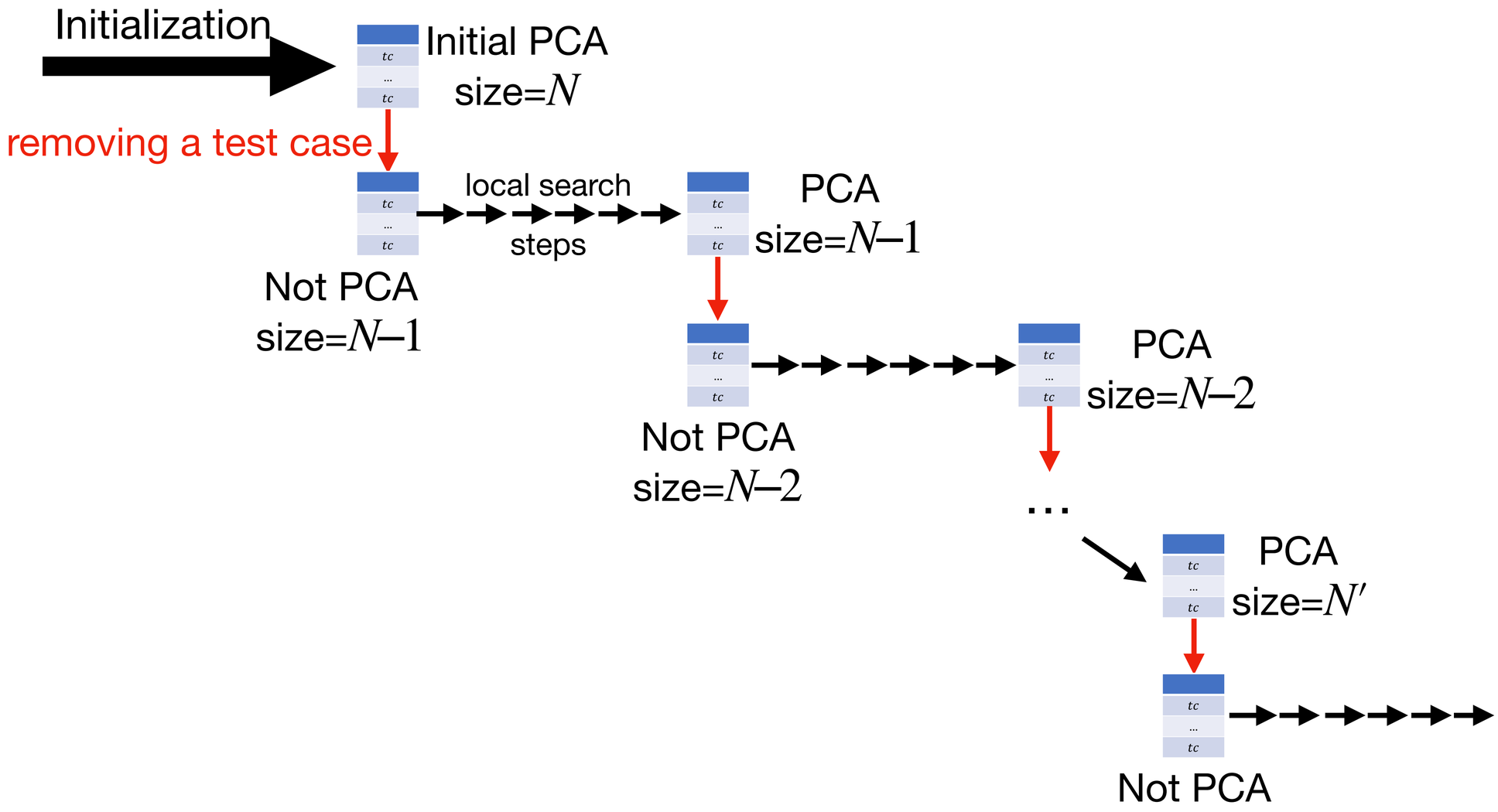

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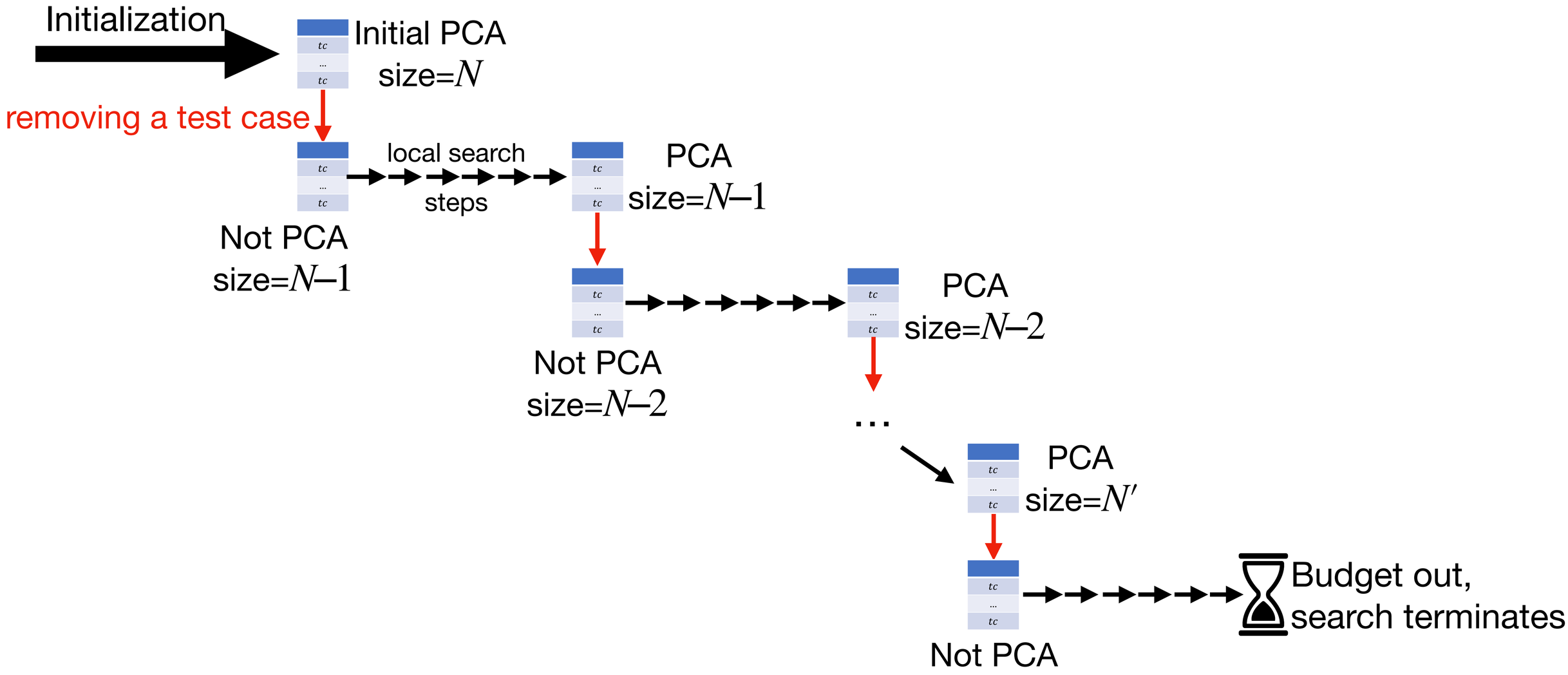

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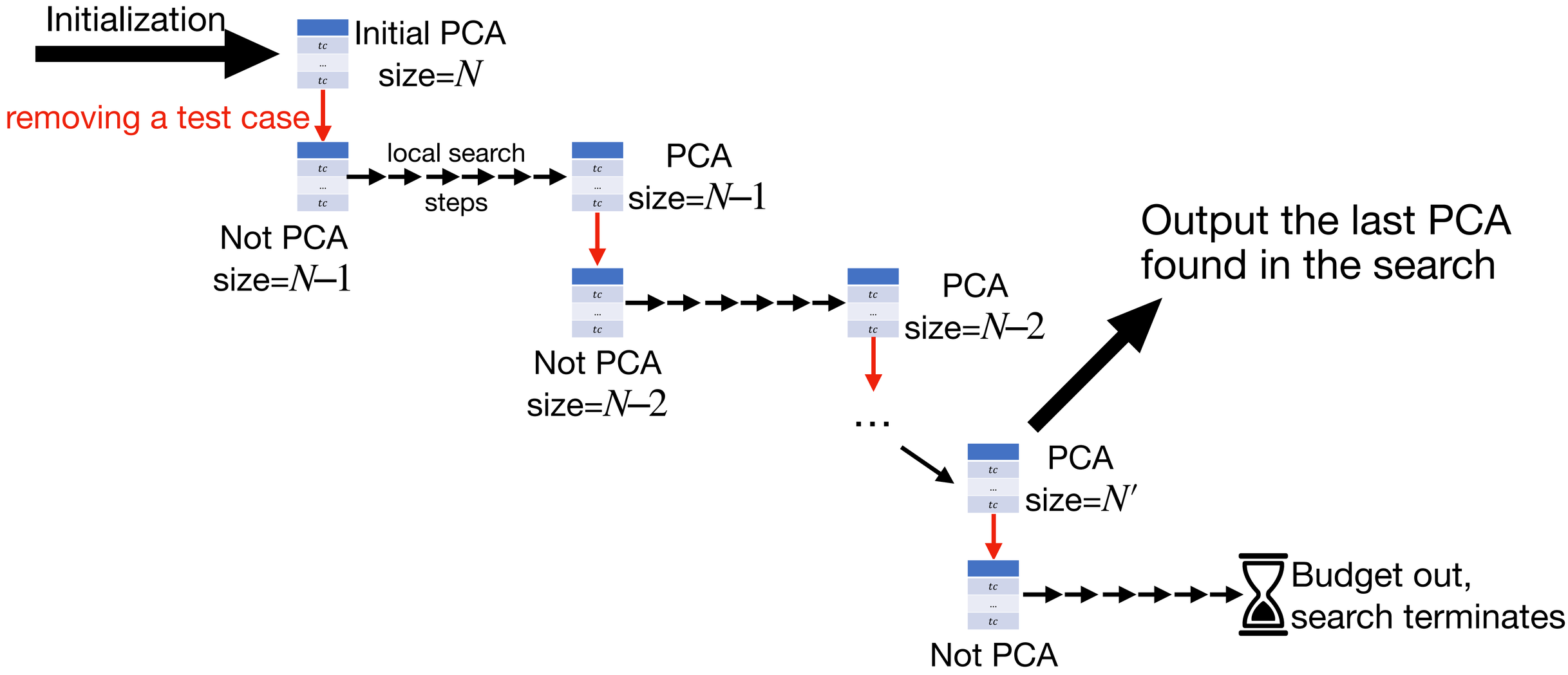

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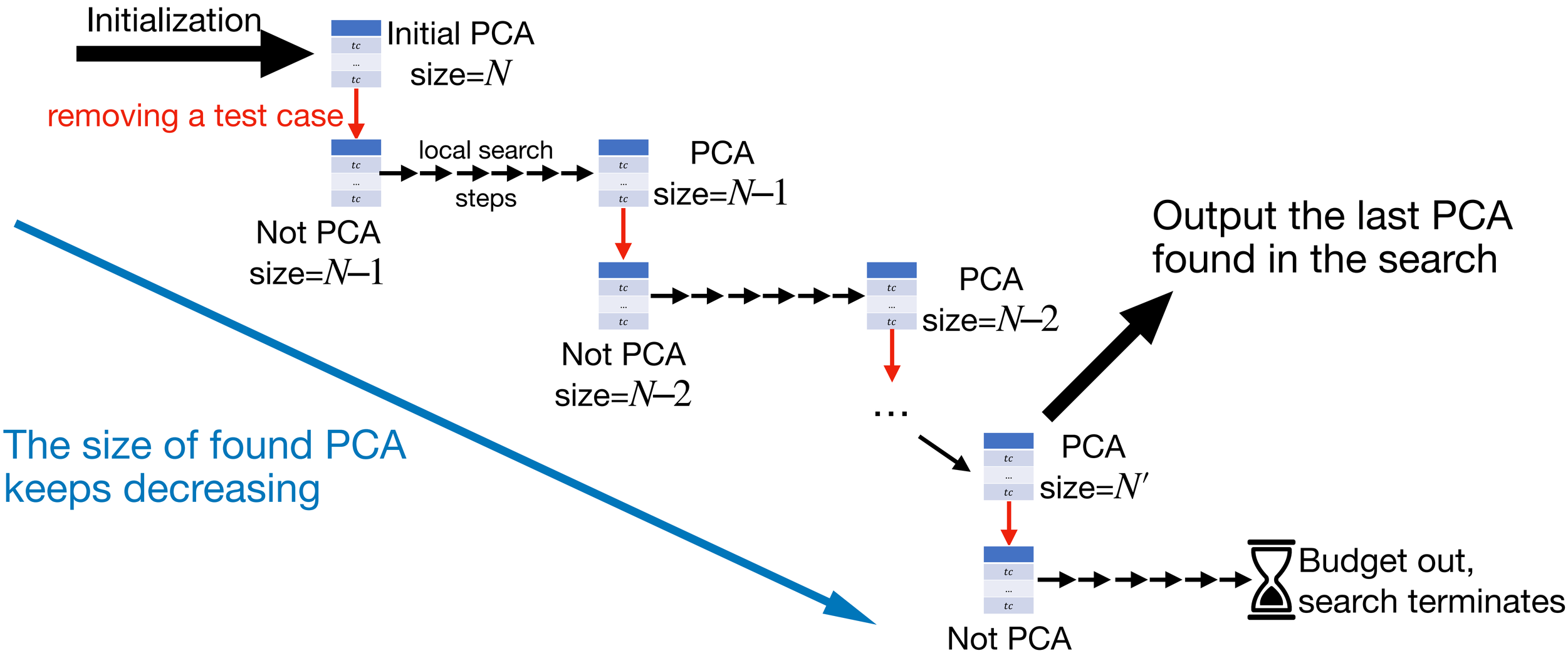

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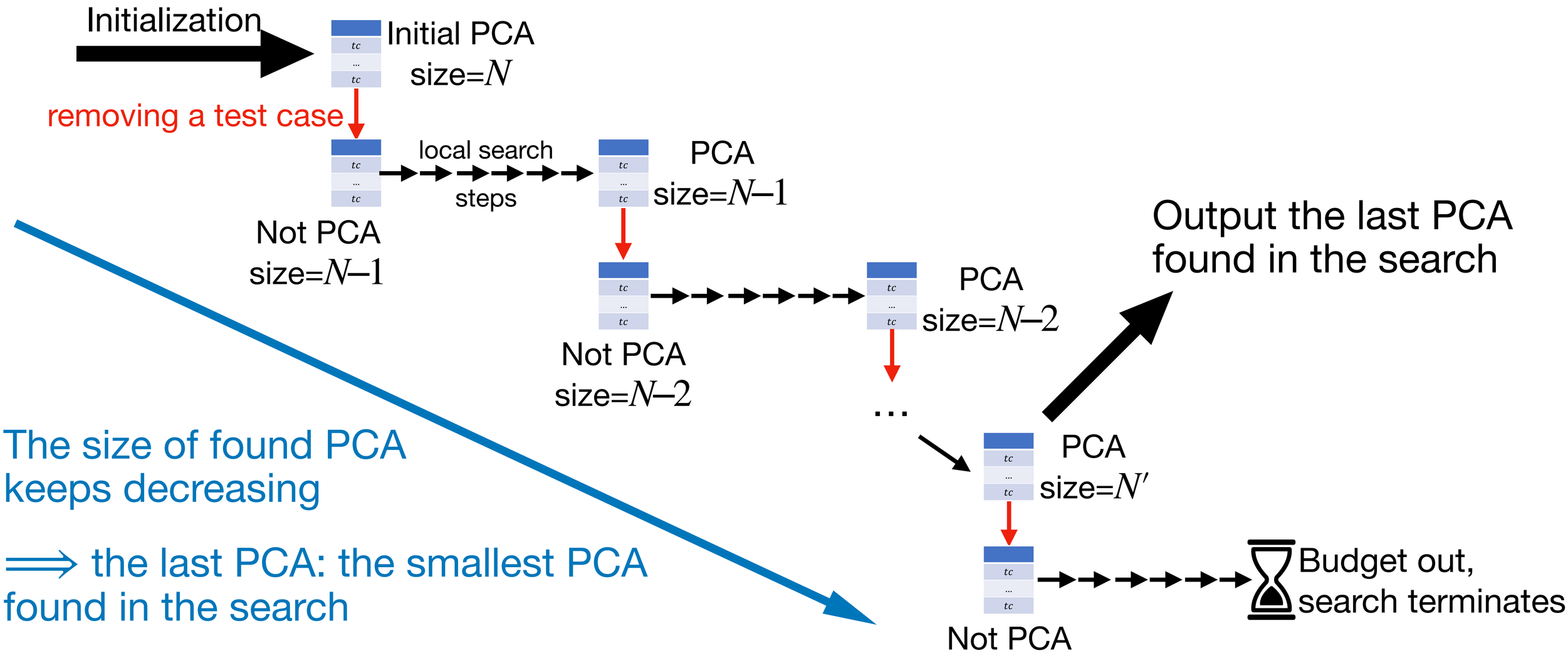

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  - Equipped with special techniques to overcome the scalability problem

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  - Making search stagnate $\Longrightarrow$ hindering PCA optimization from going further

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- State-of-the-art competitors: mainly *TCA*, *FastCA* and *AutoCCAG*
  - Competitors are given the same PCA initialized by *SamplingCA*

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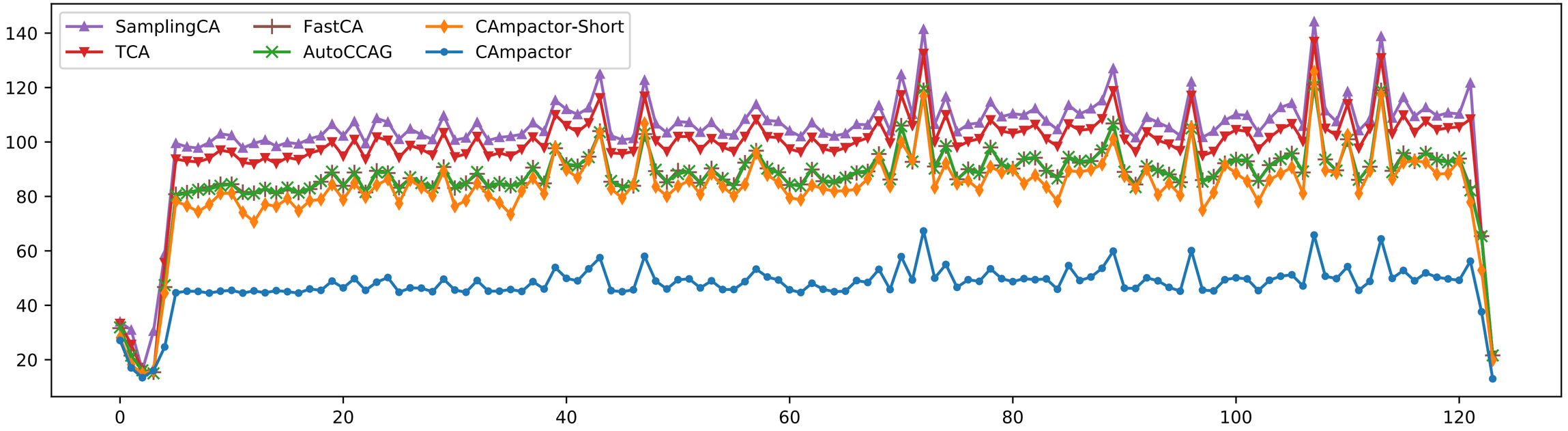

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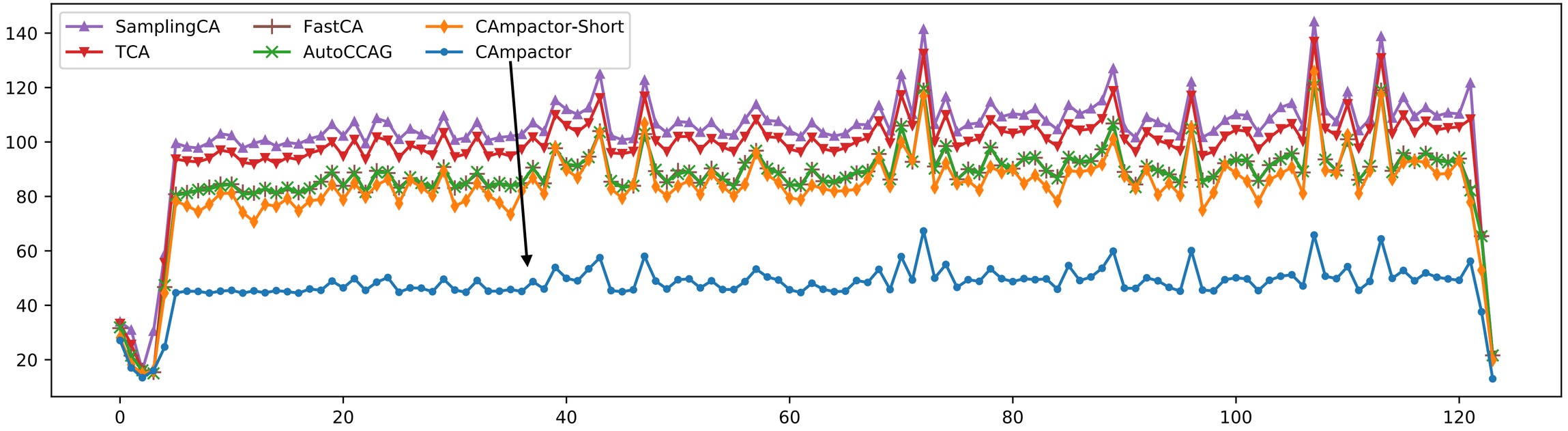

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CAmpactor-Short uses the running time of *TCA* as cutoff time

Evaluation (cont'd)

- RQ1: comparison with SOTA competitors
- Result: *CAmpactor* is also efficient
  - *CAmpactor* outperforms other competitors even if it is only allowed to run ~10 more seconds in average

	CAmpactor	*Short**	*SamplingCA*	*AutoCCAG*	*FastCA*	*TCA*
avg. size	**47.4**	82.7	104.0	86.6	86.7	98.1
avg. time	284.6	52.7	42.1	377.9	357.2	52.7

*To save space, we use '*Short*' to denote '*CAmpactor-Short*'.

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Summary

- *CAmpactor*: an novel and effective algorithm dedicated for PCA optimization
- Target: overcoming the scalability problem of PCA optimization
  - Tacking the hindering issue with forced patching
  - Mitigating the cycling issue by strengthening forbidden strategy
- Result: *CAmpactor* is effective and also moderately efficient

- For our paper and our tool: check the entry of our paper on FSE’23 website!

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Thank you for listening! 😀

Back Up

RQ2: Ablation Study

- Alt-1: *CAmpactor* minus test case level forbidden strategy
- Alt-2: *CAmpactor* minus test case level forbidden strategy, plus single value level forbidden strategy
- Alt-3: *CAmpactor* minus forced patching

Table 3: Average size and average running time of *CAmpactor* and all its alternative versions over all instances.

	CAmpactor	*Alt-1*	*Alt-2*	*Alt-3*
avg. size	**47.4**	79.8	54.3	98.6
avg. time	284.6	67.3	278.7	46.1

RQ4: Generality of *CAmpactor*

- Alt-A/F/T: using *CAmpactor* to optimize the output PCA from *AutoCCAG*/*FastCA*/*TCA*

Table 7: Average size and average running time of *AutoCCAG*, *FastCA*, *TCA*, *Alt-A*, *Alt-F* and *Alt-T* over all instances.

	AutoCCAG	*Alt-A*	*FastCA*	*Alt-F*	*TCA*	*Alt-T*
avg. size	86.6	47.4	86.7	**47.3**	98.1	**47.3**
avg. time	377.9	611.1	357.2	591.5	52.7	293.4