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OpenNTT

An Automated Toolchain for Compiling High-Performance NTT and FFT Accelerators

Florian Krieger Florian Hirner Ahmet Can Mert Sujoy Sinha Roy

Optimist Workshop 2025

Outline

The NTT in Modern Cryptography

- Cornerstone of modern cryptography

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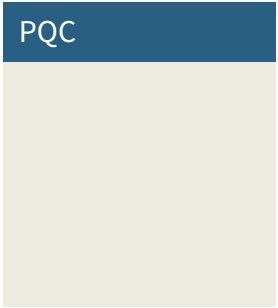

The NTT in Modern Cryptography

- Cornerstone of modern cryptography

PQC

- **NIST:** 3

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$N \approx 2^8$
$\log Q < 32$ bits

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$N \approx 2^{16}$
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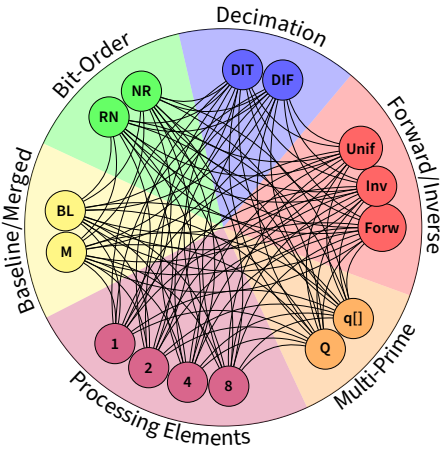
$N \approx 2^{30}$
$\log Q \approx 384$ bits

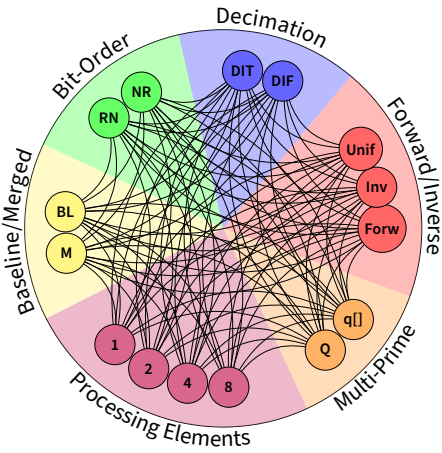
Motivation

- Many different configurations



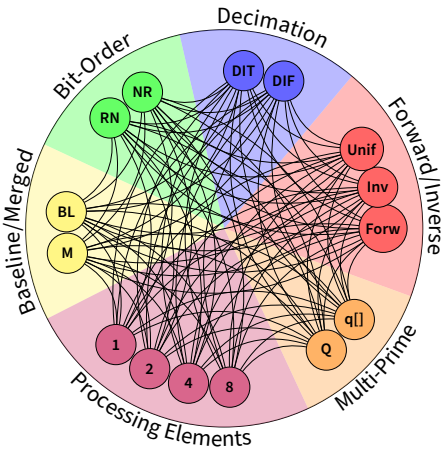
Motivation

- Many different configurations
- Performance bottleneck
  - ➔ Hardware acceleration



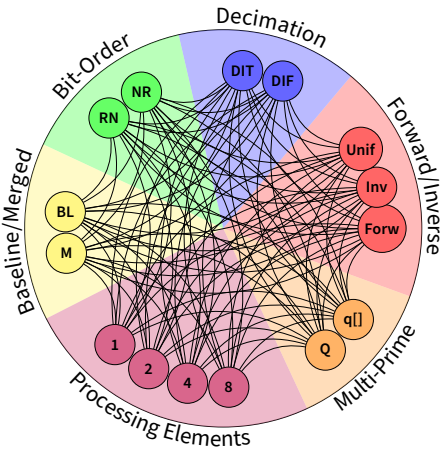
Motivation

- Many different configurations
- Performance bottleneck
  - ➔ Hardware acceleration
- Often processing secret data
  - ➔ Side-channel countermeasures



Designing Hardware Accelerators is Challenging

- High design effort for each design...



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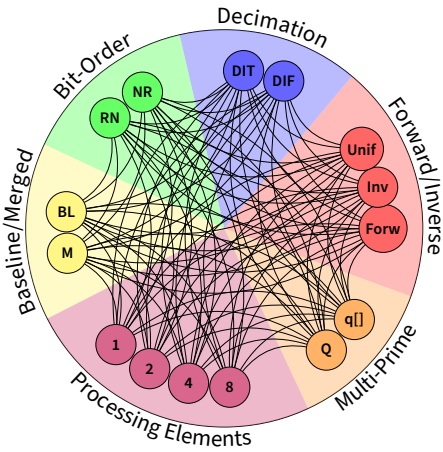

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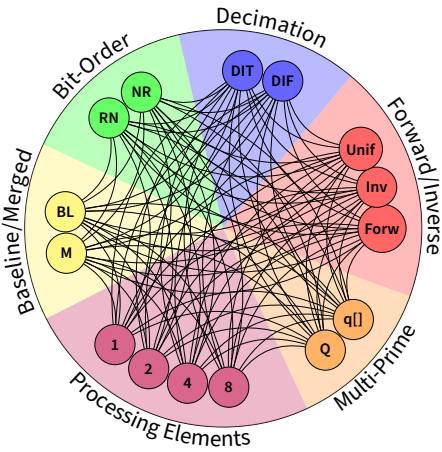
- ...to reach high performance



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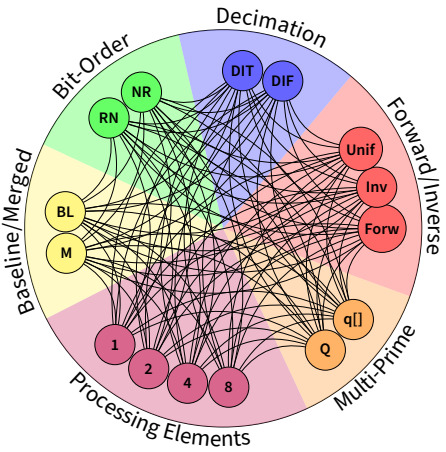
- ...to adapt to target platform



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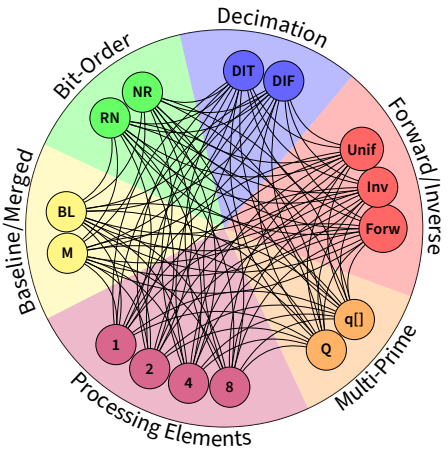
Hardware design as simple as running a Python script?



OpenNTT

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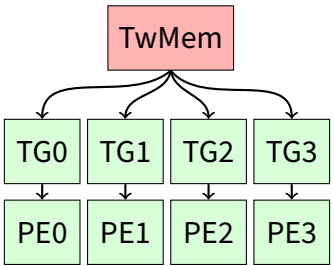
- Easy to use
- First tool with on-the-fly twiddle factor generation
- Highly performant
  - Platform-aware optimization techniques

The MemOpt Technique



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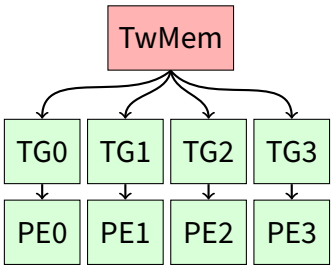

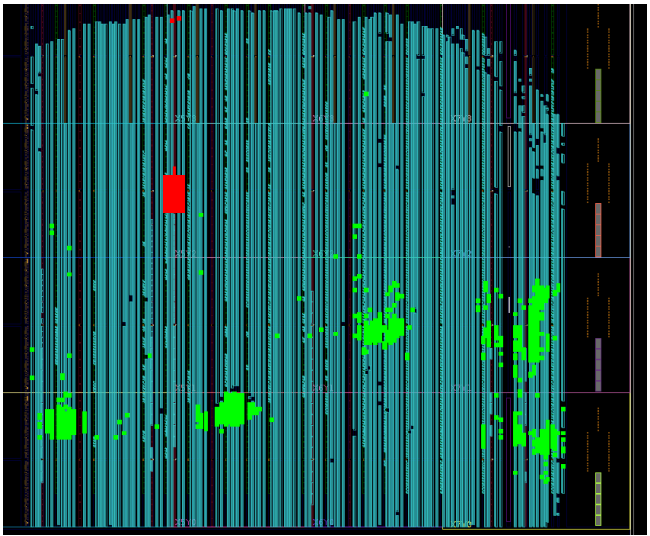

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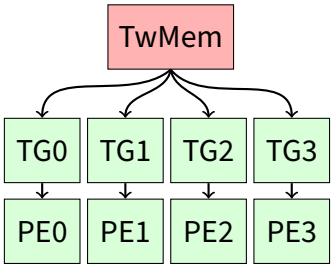
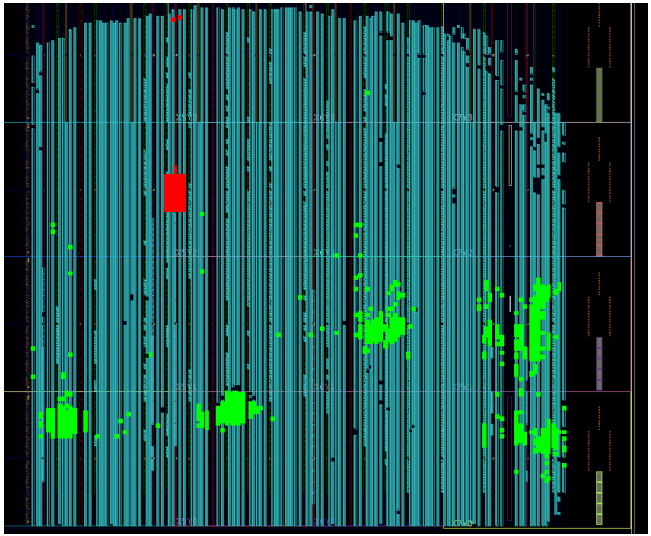
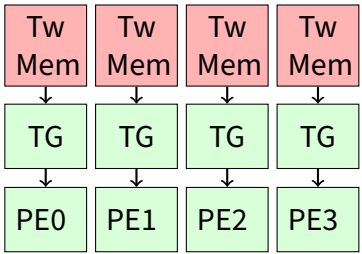


→ Minimizes memory usage



The RoutOpt Technique



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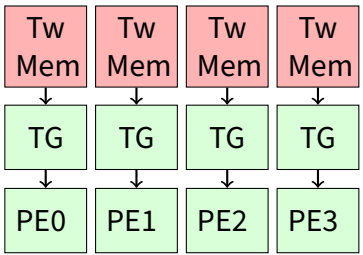

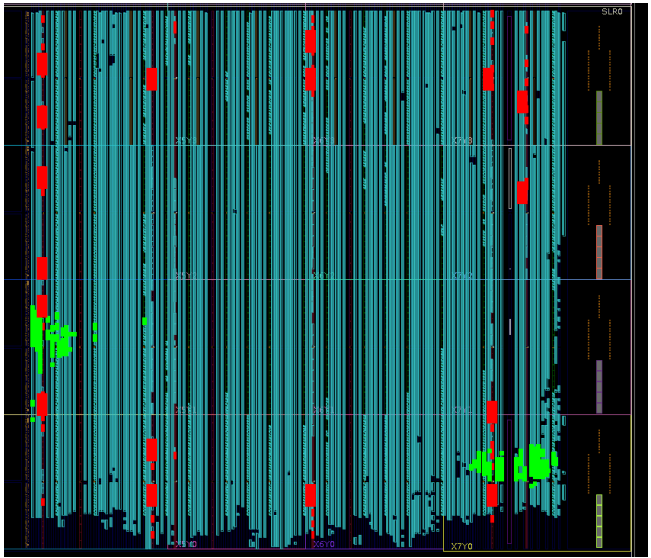

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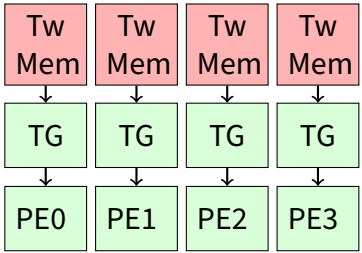
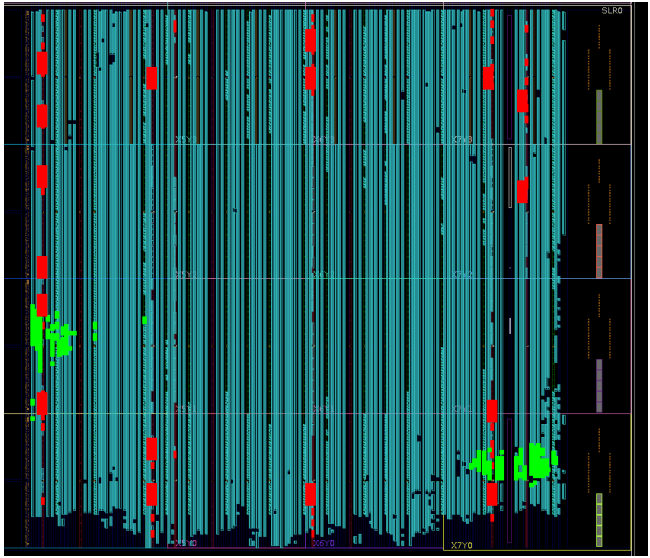
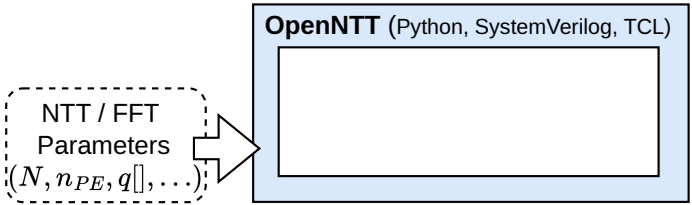


➔ Improves frequency by up to 20%



Applications of OpenNTT

The OpenNTT Workflow




```
python3 openntt.py -transf_type=NTT -memory_opt=0 -ntt_type=mfntt_dit_nr
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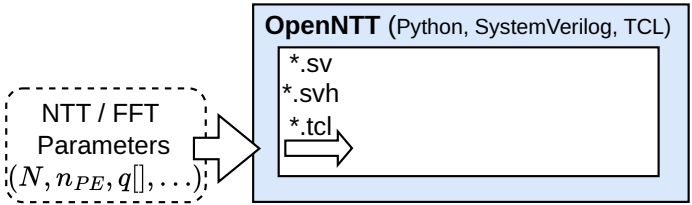


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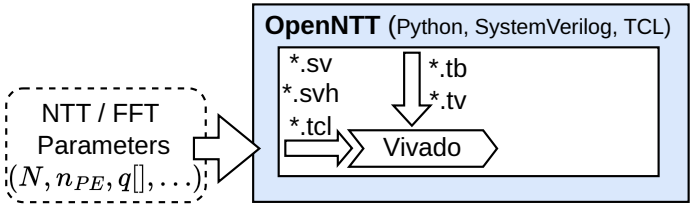


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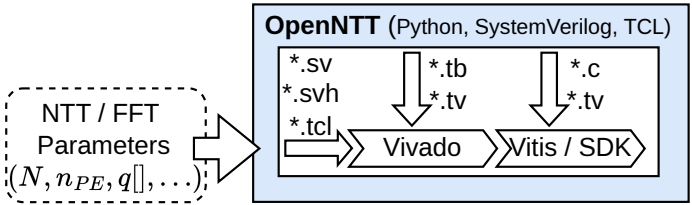


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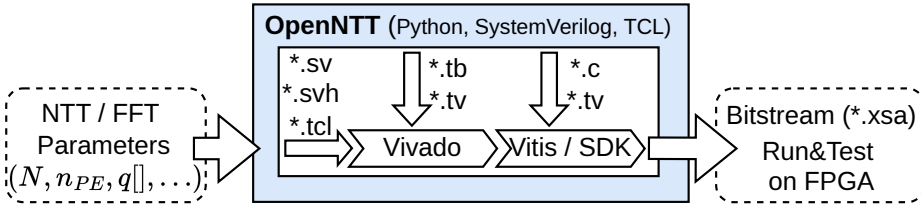


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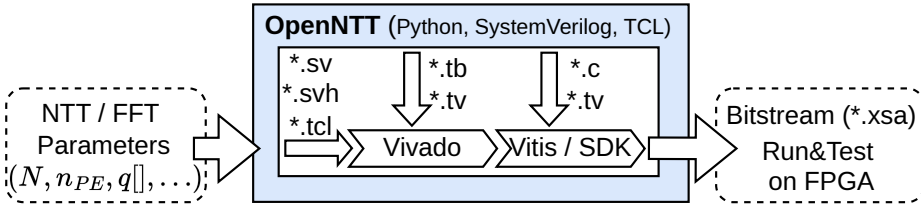


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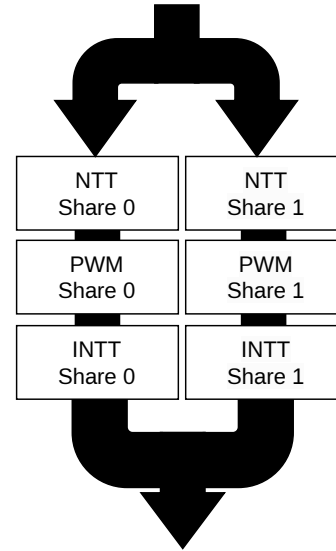
Example: Masked PQC Accelerator

- OpenNTT generates NTT module
  - ...using parameters from specification



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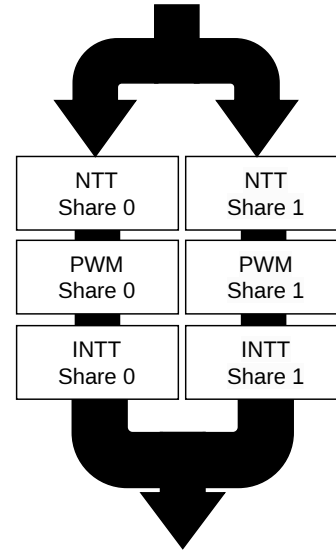
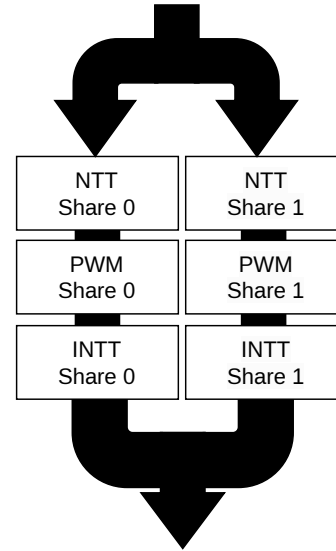
- Instantiating the module twice
  - each module operates on one share



Example: Masked PQC Accelerator

- OpenNTT generates NTT module
  - ...using parameters from specification
- Instantiating the module twice
  - each module operates on one share
- Ongoing work:
  - Offering optimizations for masking
  - Shuffling support for hiding



Example: Client-Side CKKS Accelerator

- CKKS client needs NTT and FFT

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- Use OpenNTT to compile NTT and FFT modules

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- CKKS client needs NTT and FFT
- Use OpenNTT to compile NTT and FFT modules
- 1.9× more efficient than state-of-the-art designs [Kri+24]

Conclusion

- Difficult to provide generic NTT/FFT design tools

github.com

Paper

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- OpenNTT is very easy to use

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Conclusion

- Difficult to provide generic NTT/FFT design tools
- OpenNTT is very easy to use
  - Parameter flexible
  - Platform aware
  - Applies to many different applications

github.com

Paper

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Bibliography

[Kri+24] Florian Krieger et al. **Aloha-HE: A Low-Area Hardware Accelerator for Client-Side Operations in Homomorphic Encryption**. 2024 Design, Automation and Test in Europe Conference and Exhibition (DATE). 2024, pp. 1–6. DOI: 10.23919/DATE58400.2024.10546608.