Truncated Differential Cryptanalysis of Five Rounds of Salsa20

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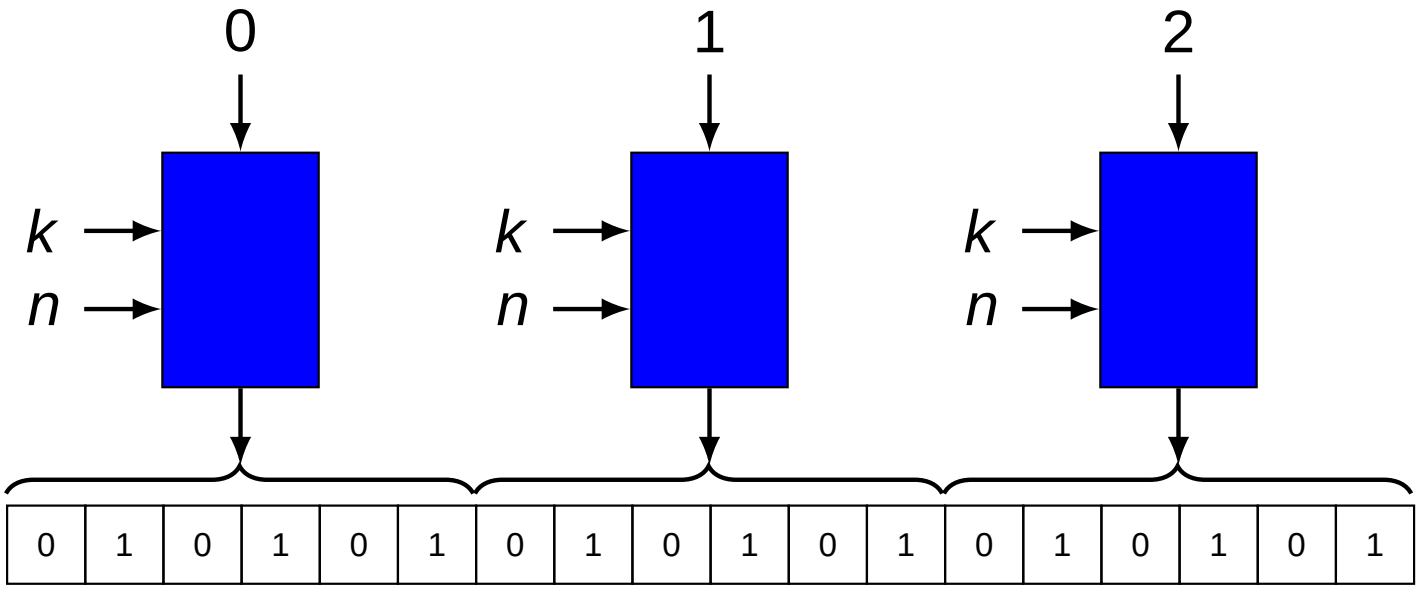
LShift Ltd

State of the Art in Stream Ciphers 2006

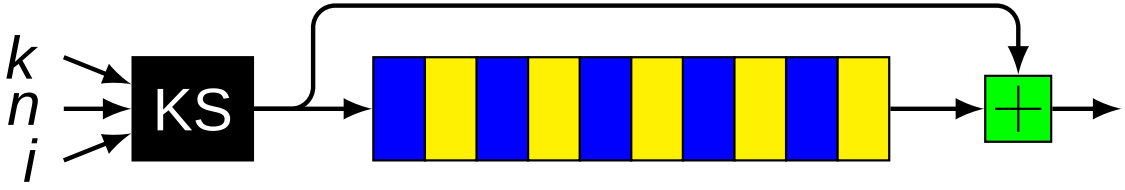
Salsa20

- eSTREAM entrant by Daniel J Bernstein
- Block-cipher-like structure
- 20 rounds, 256-bit key
- 5 round key recovery needs 4096 bytes and 2^{165} work

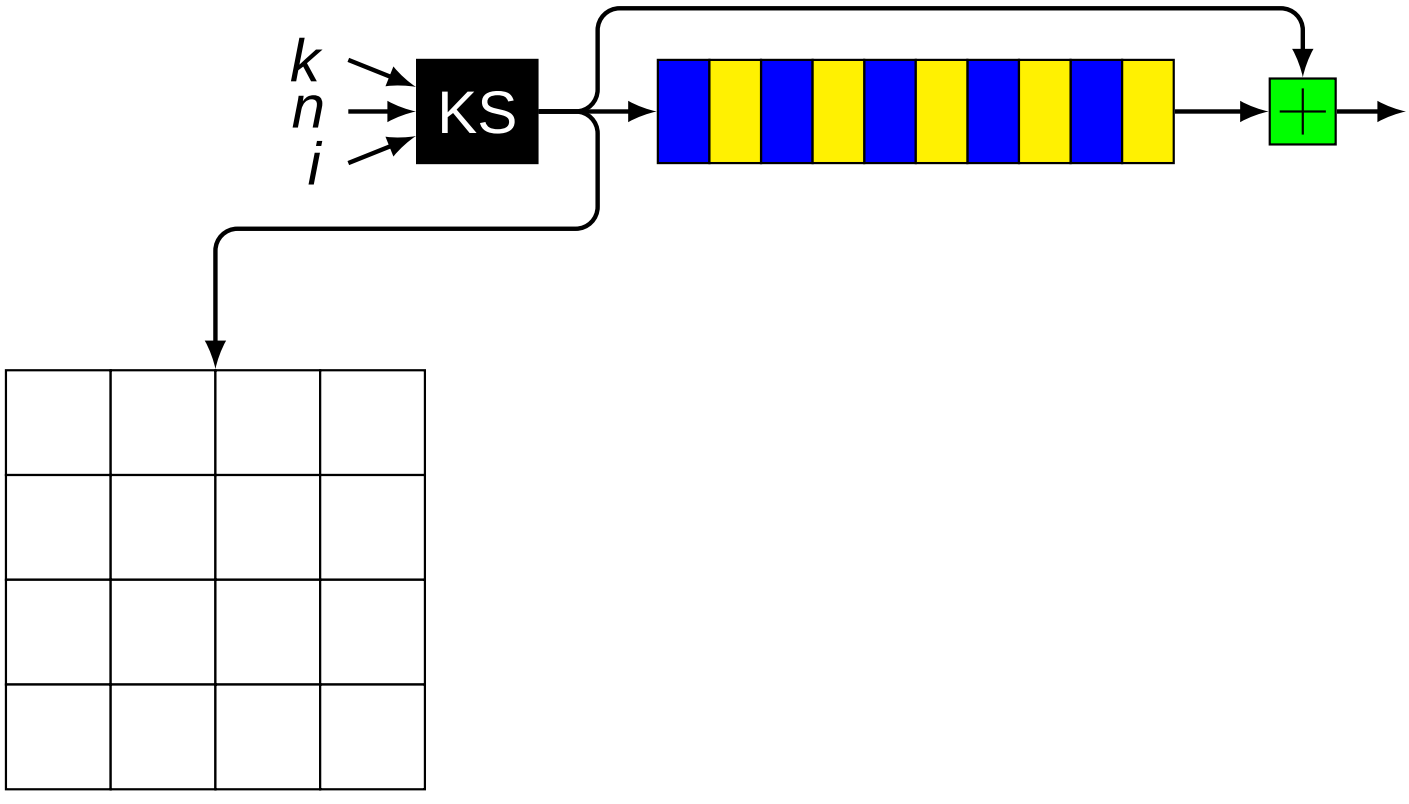
Seekable output



PRF



Key schedule



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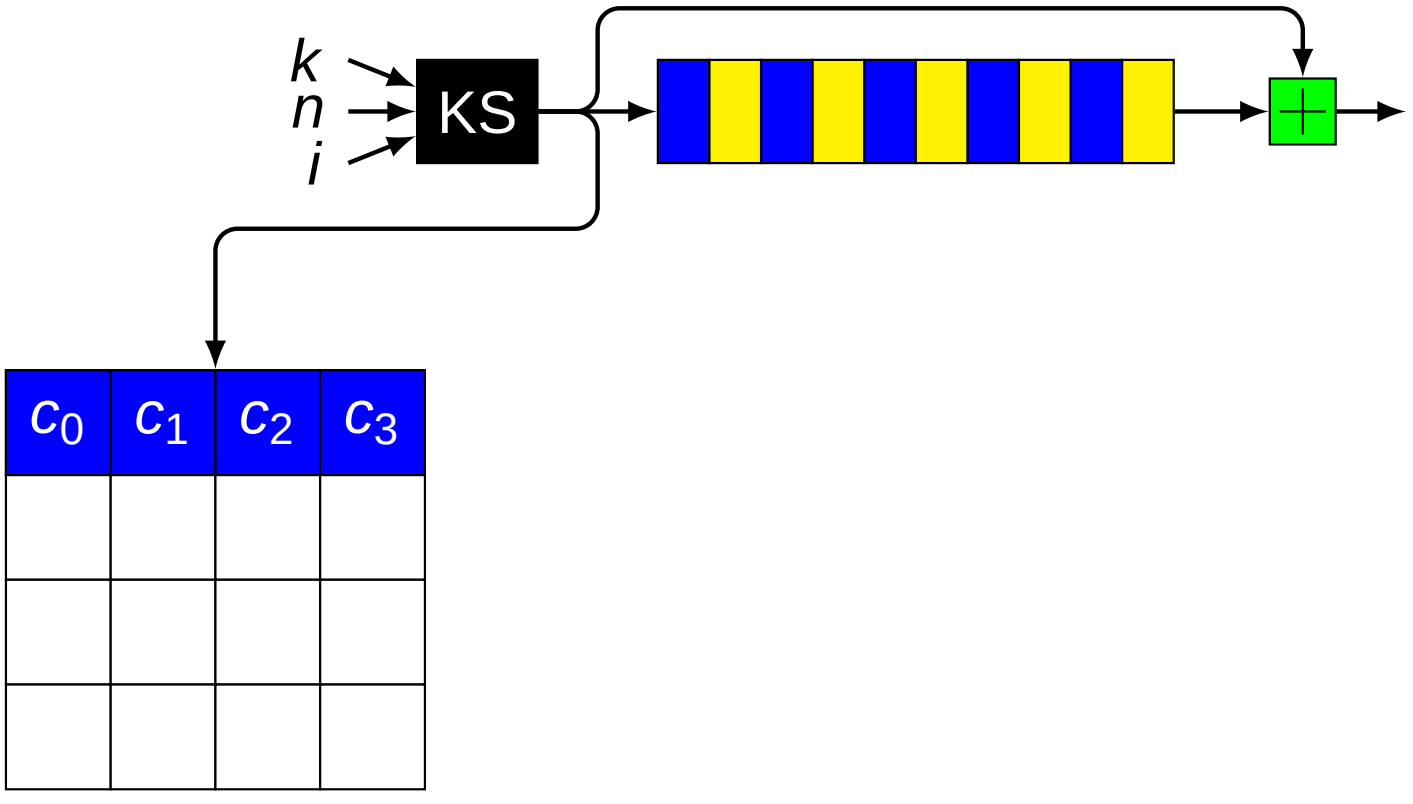

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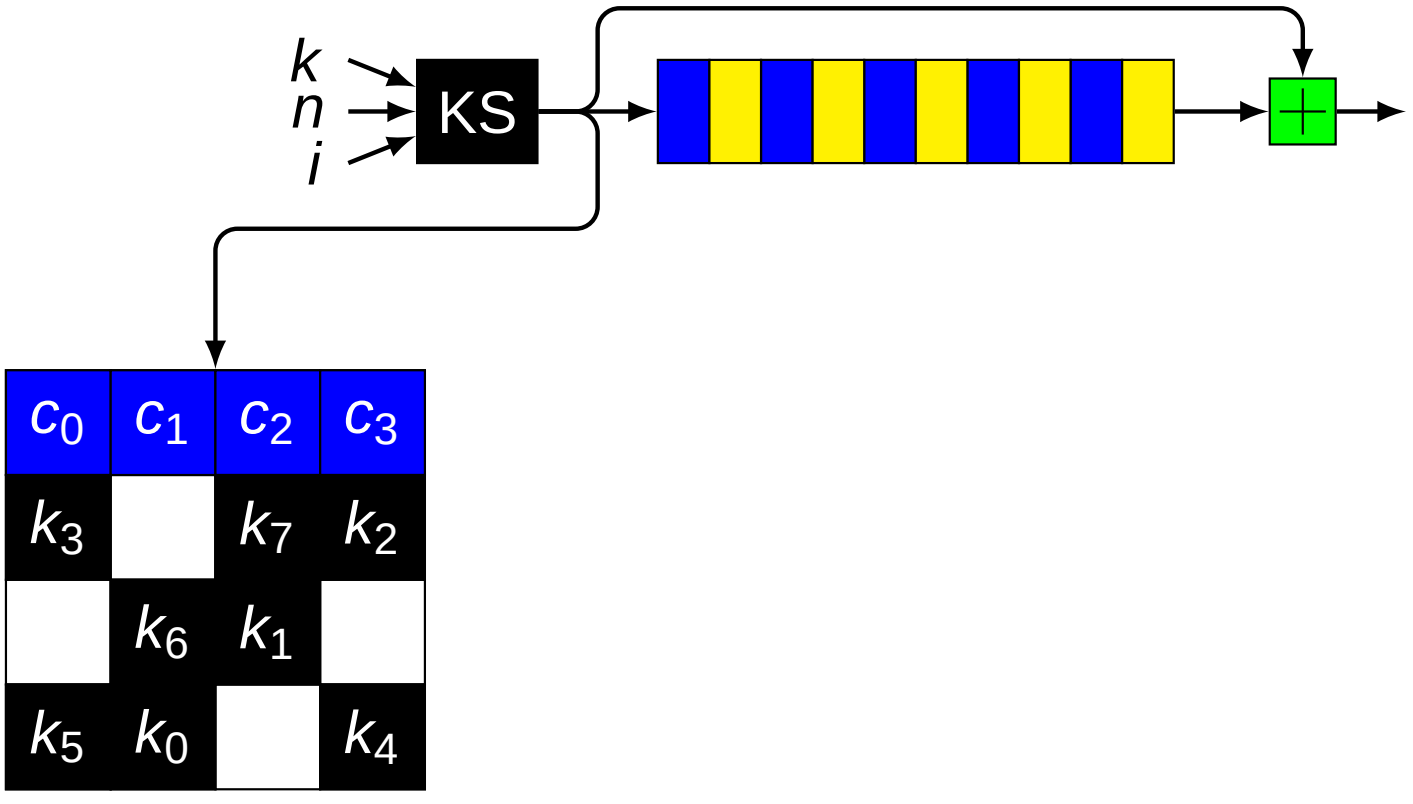

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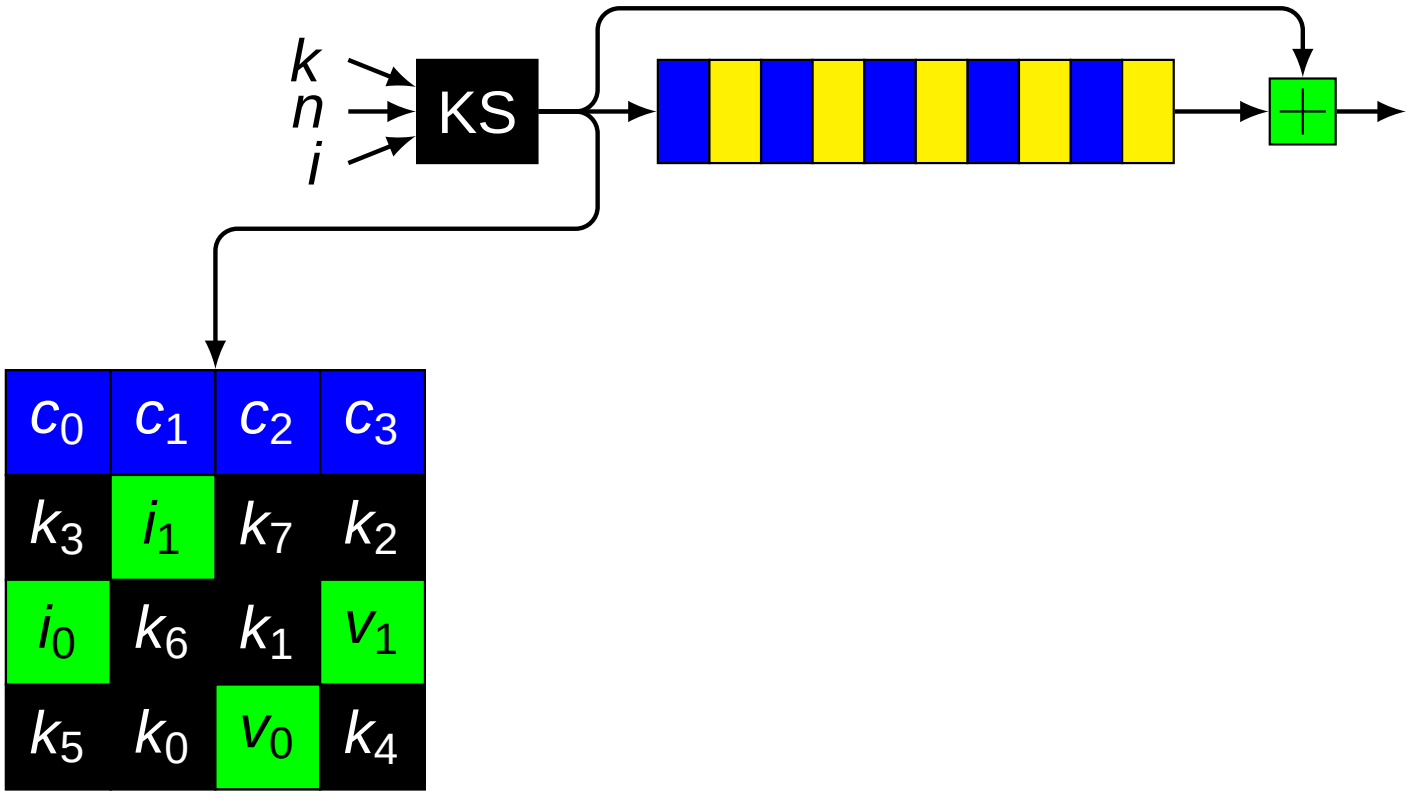
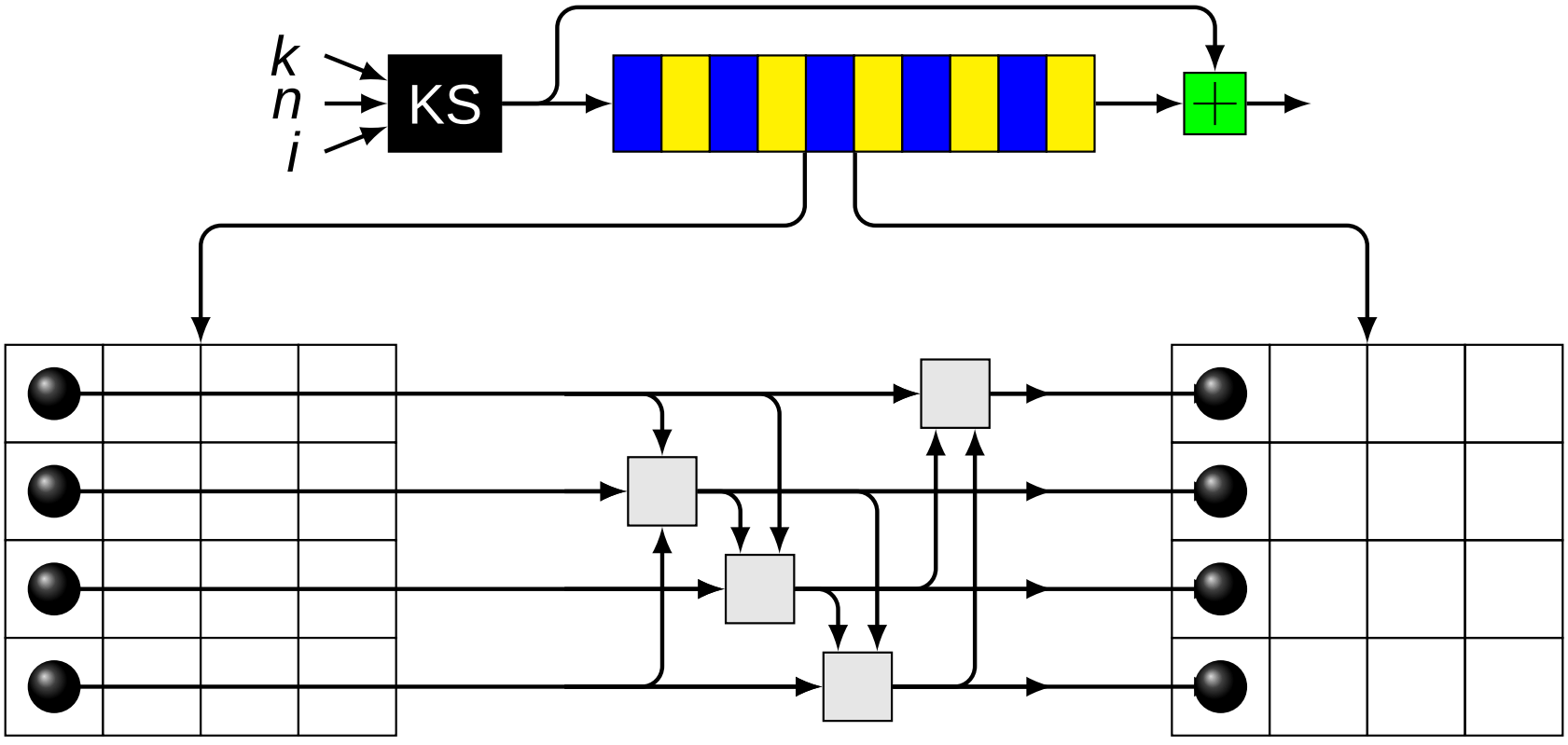


Mixing



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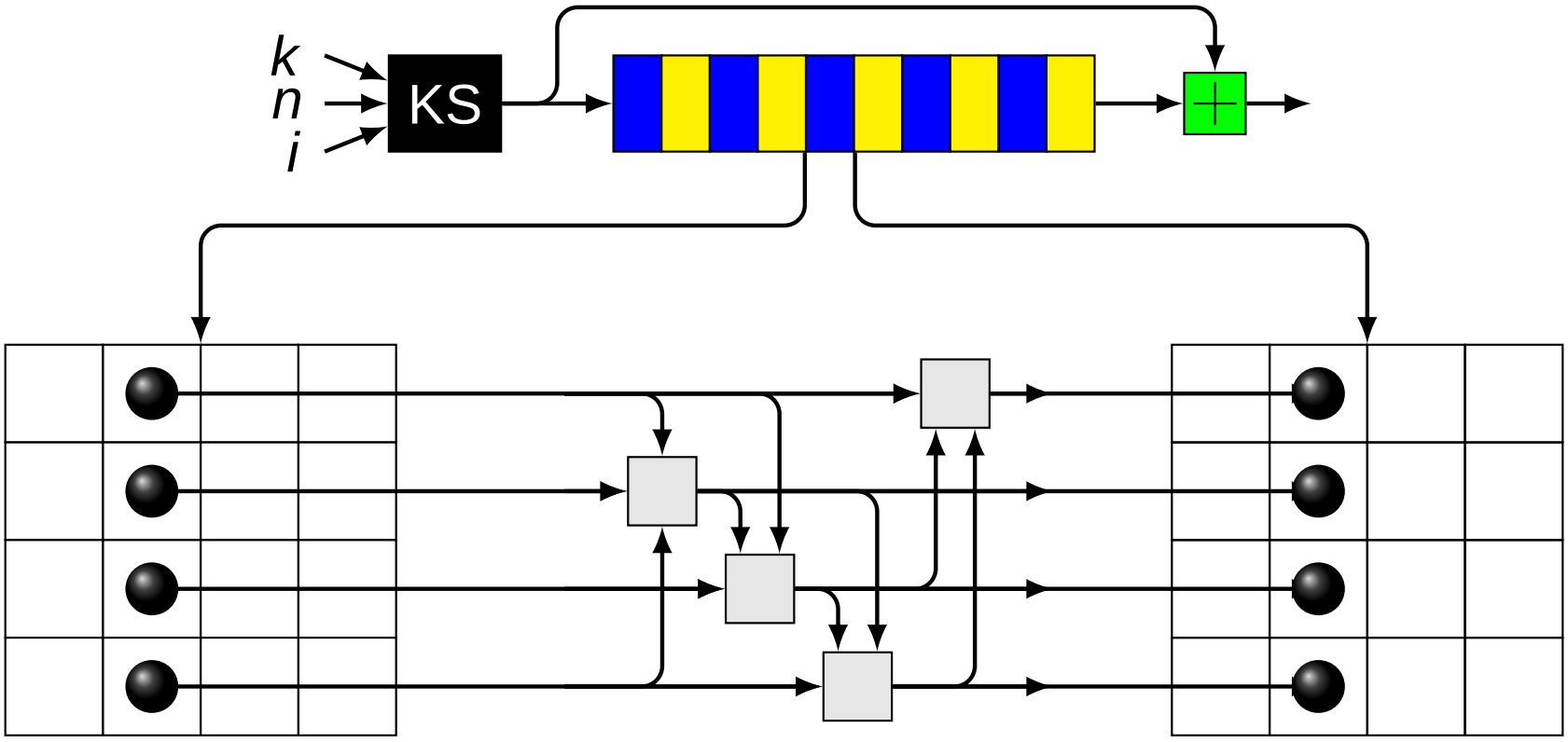

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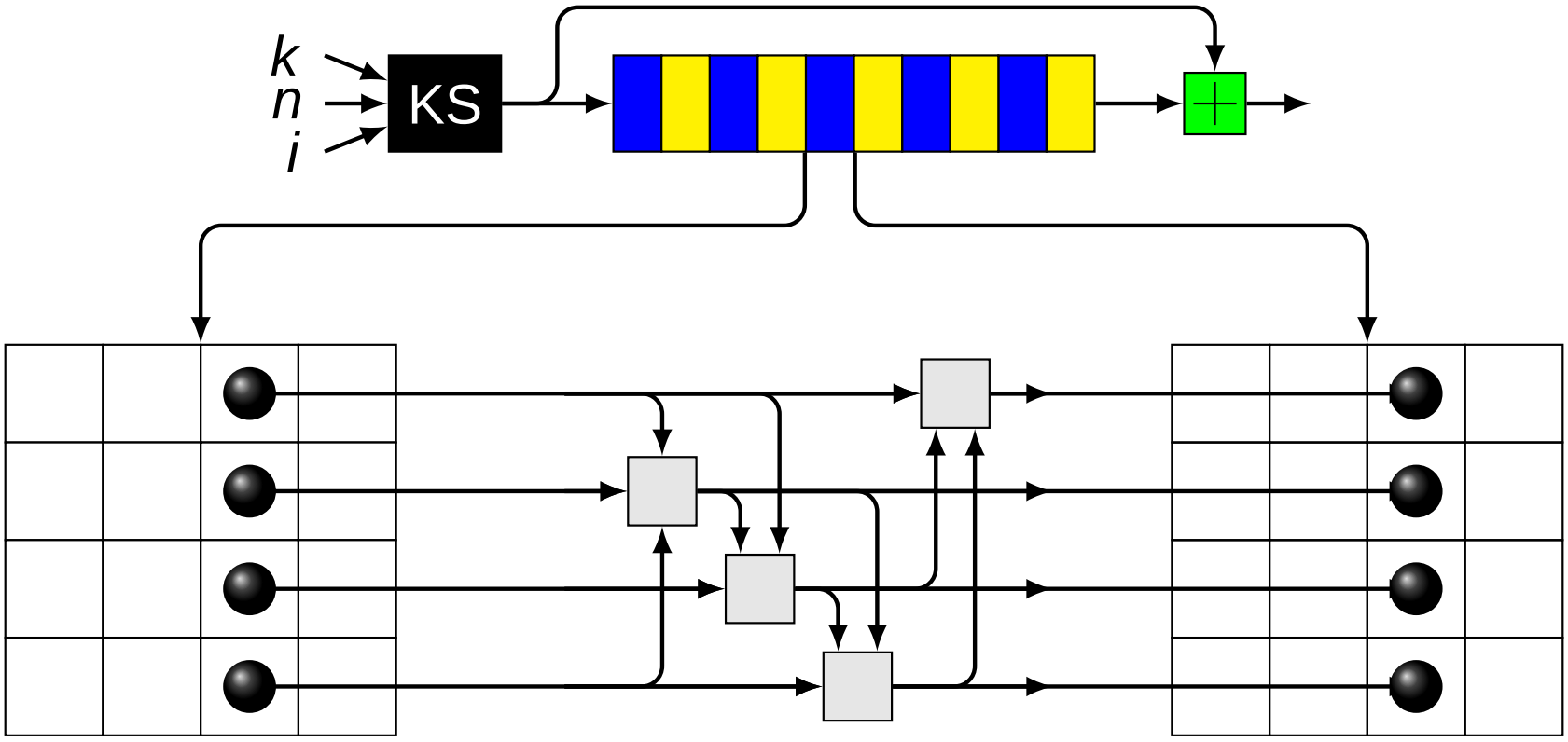

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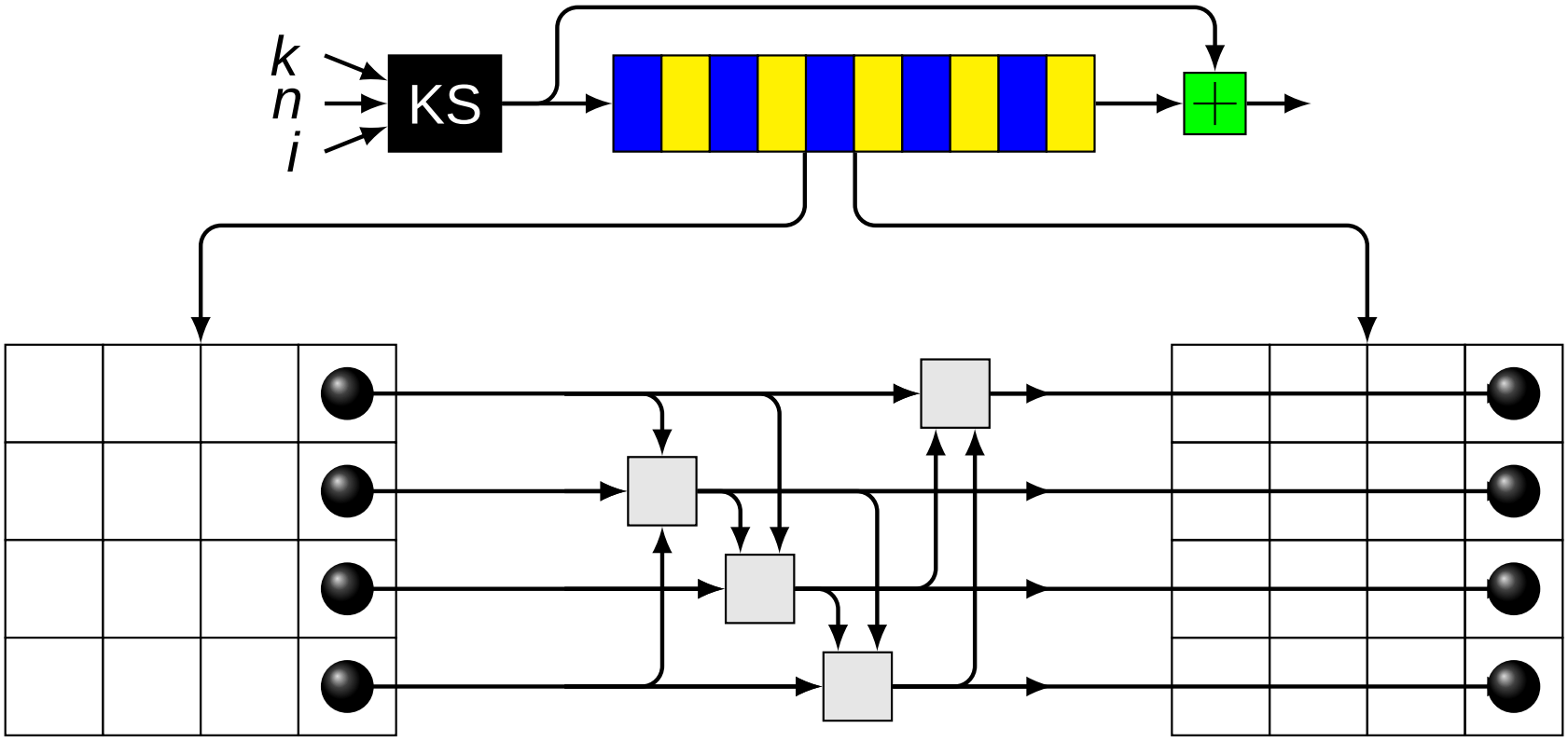

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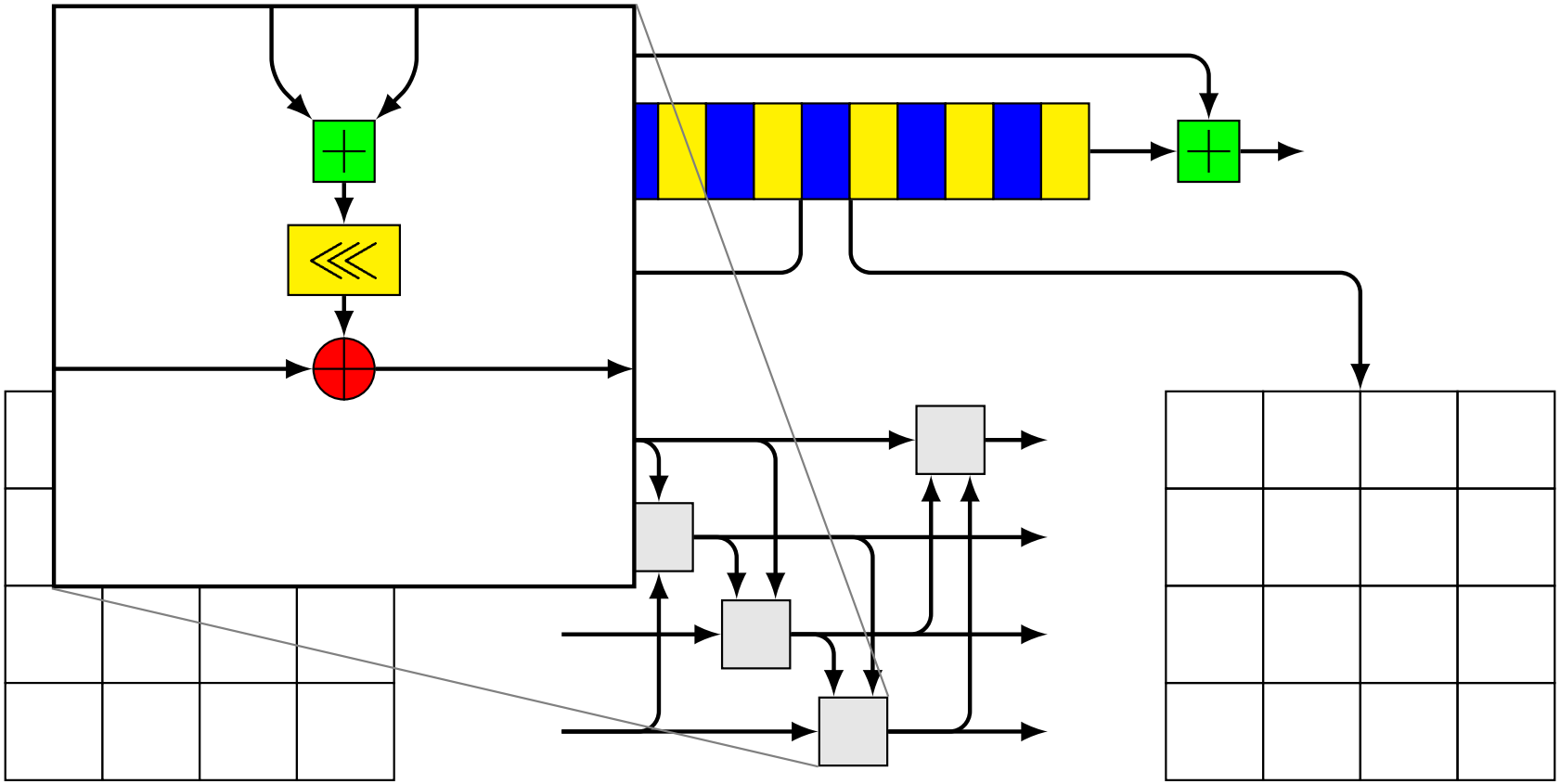
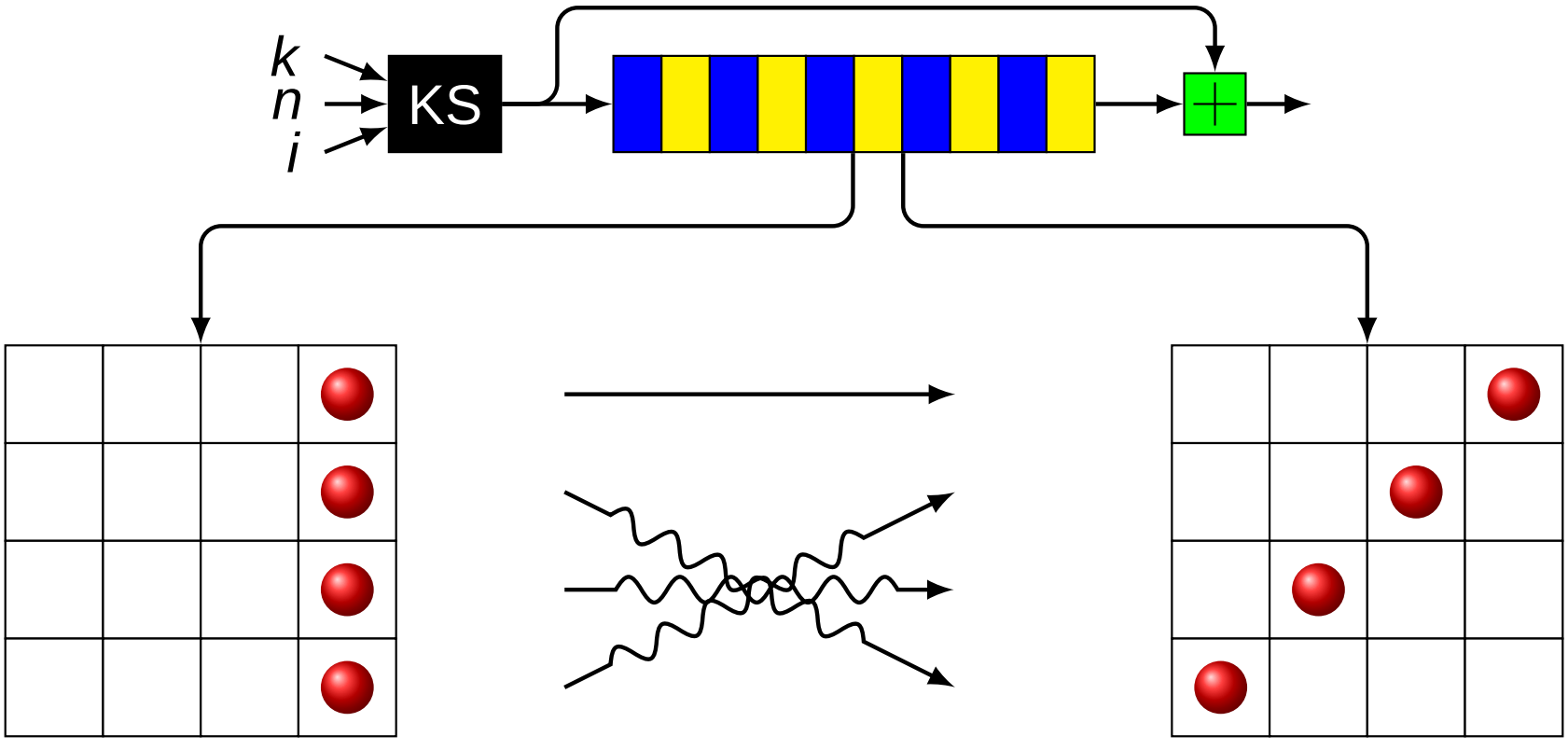
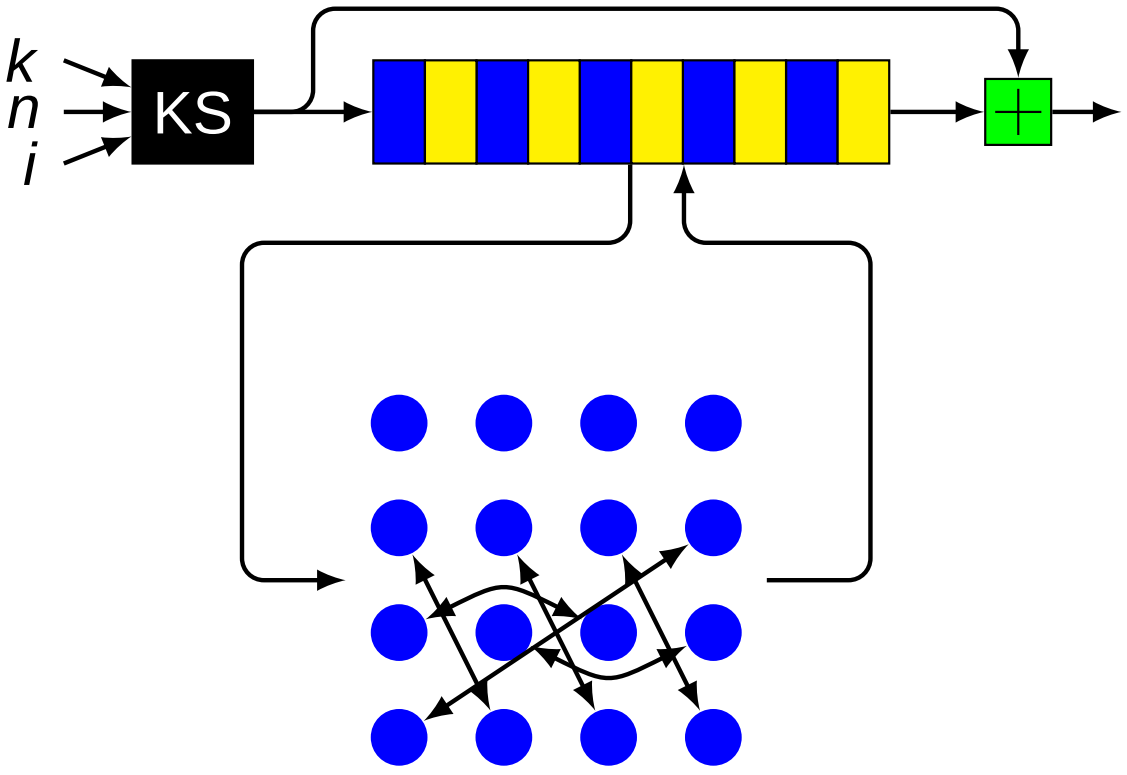


Shuffling



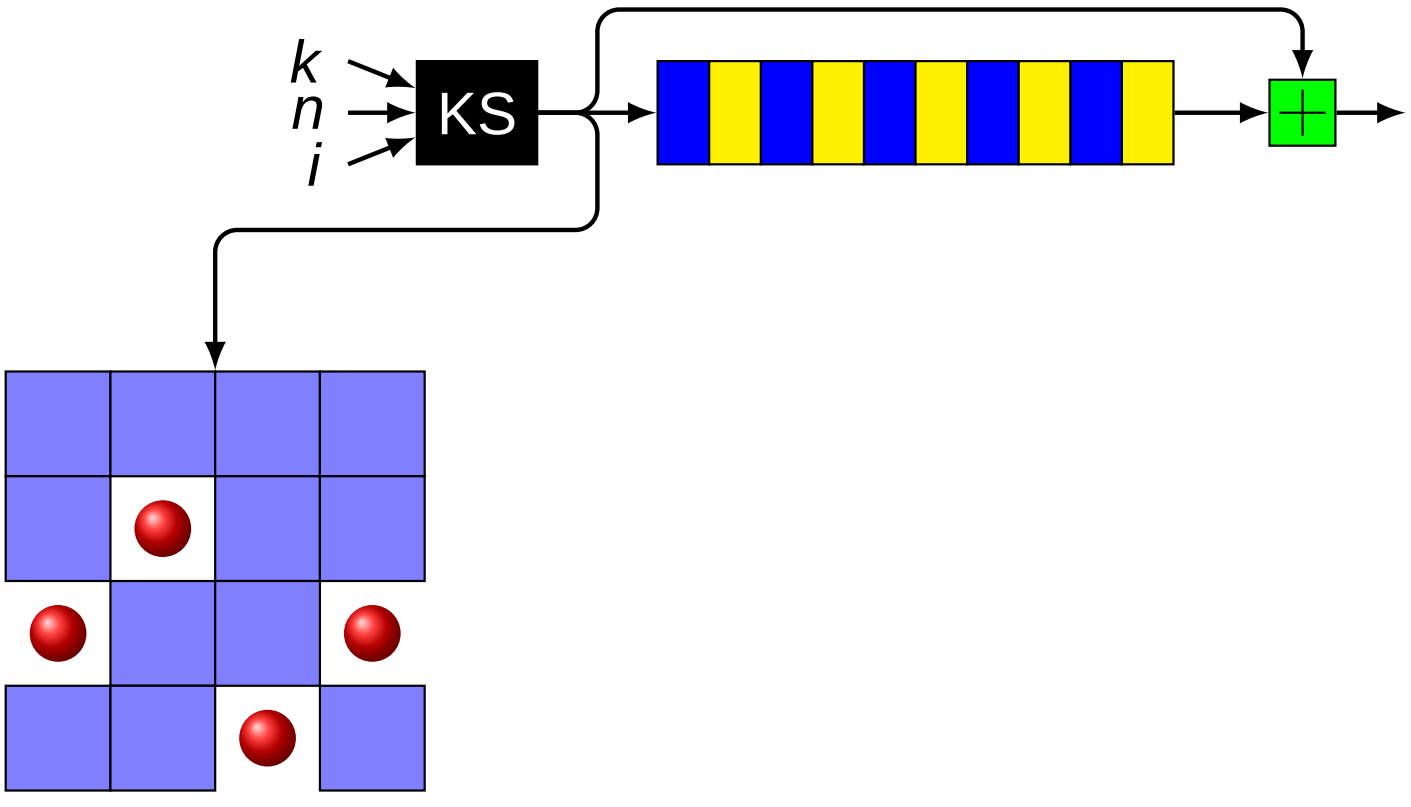
Shuffling



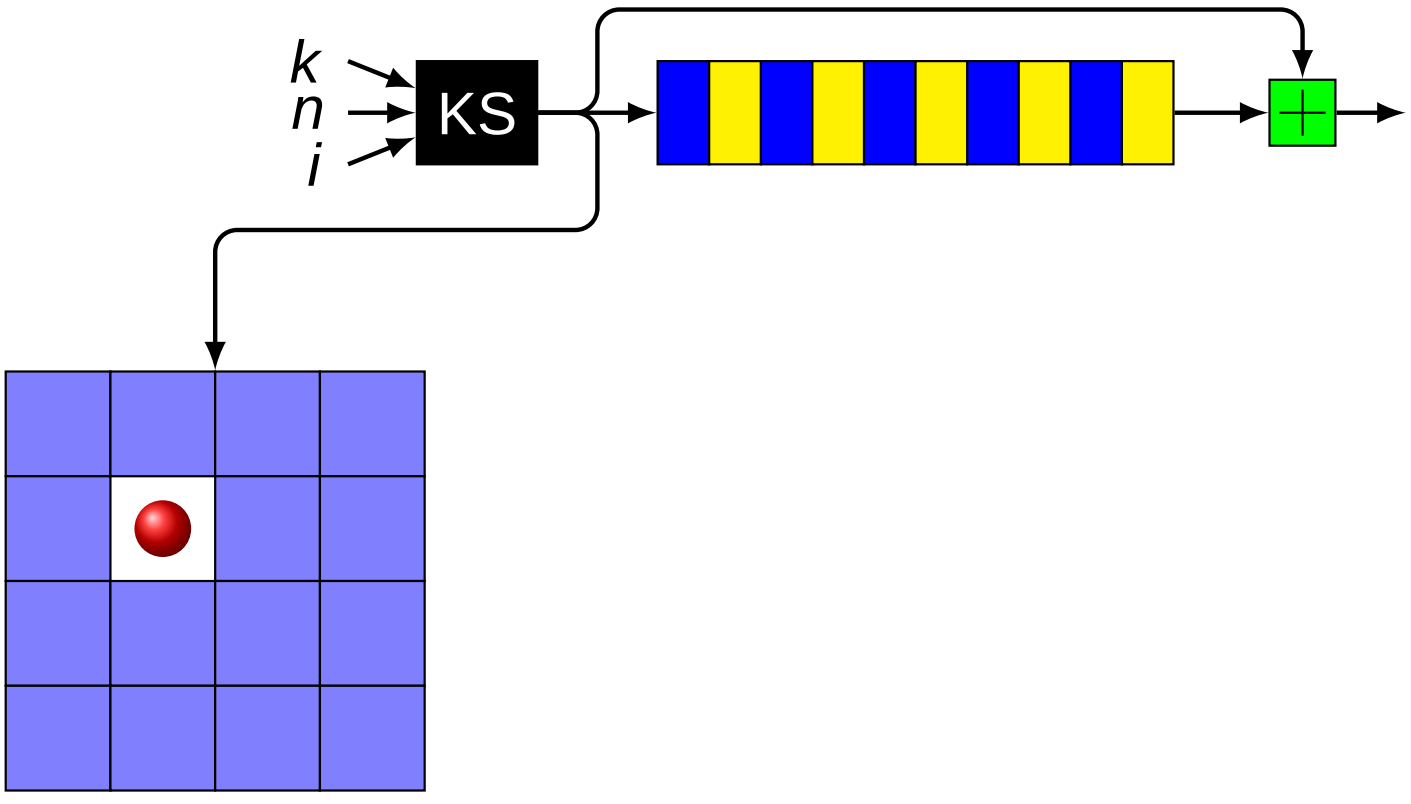
Our attack

- Differential attack
- Truncated differentials

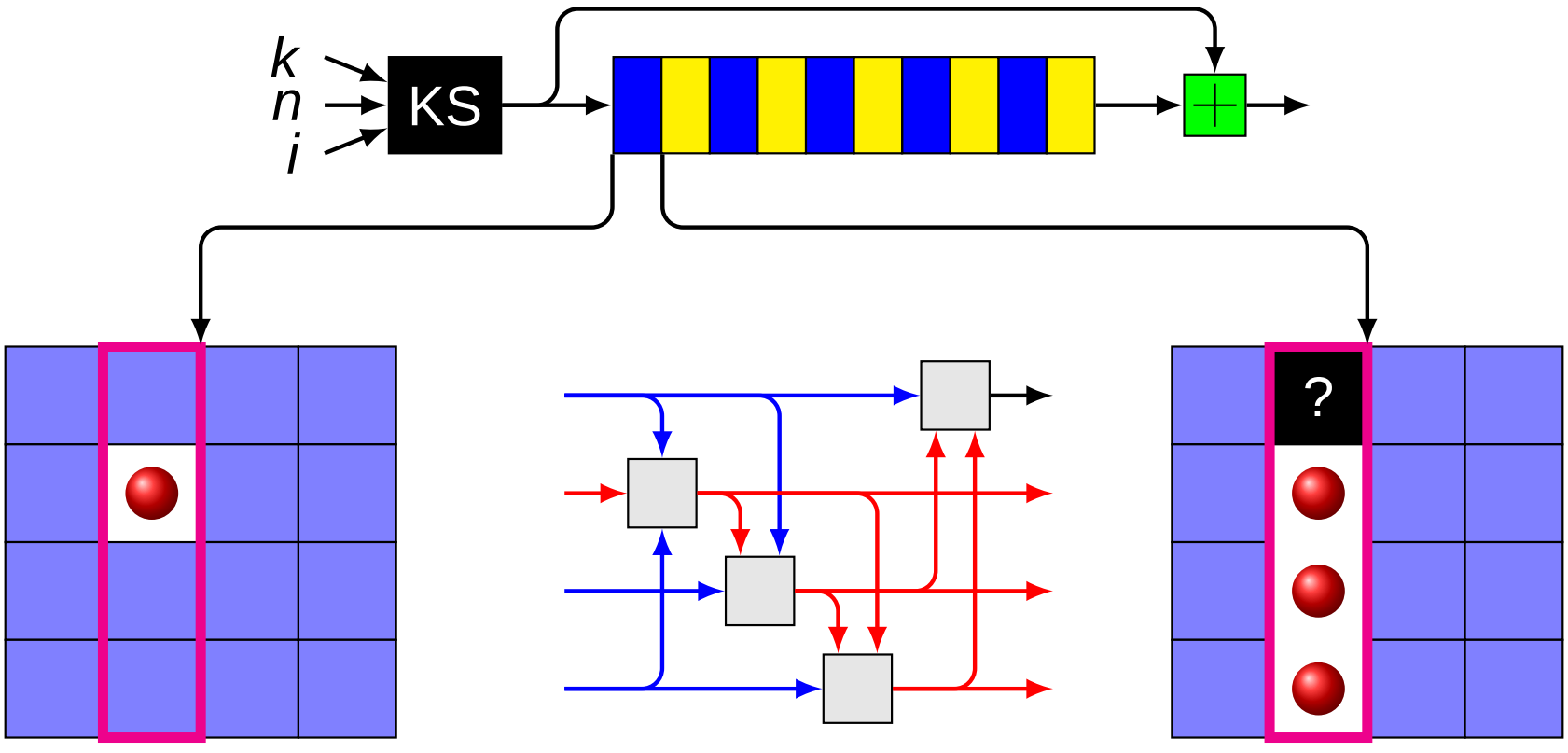
Differential characteristic



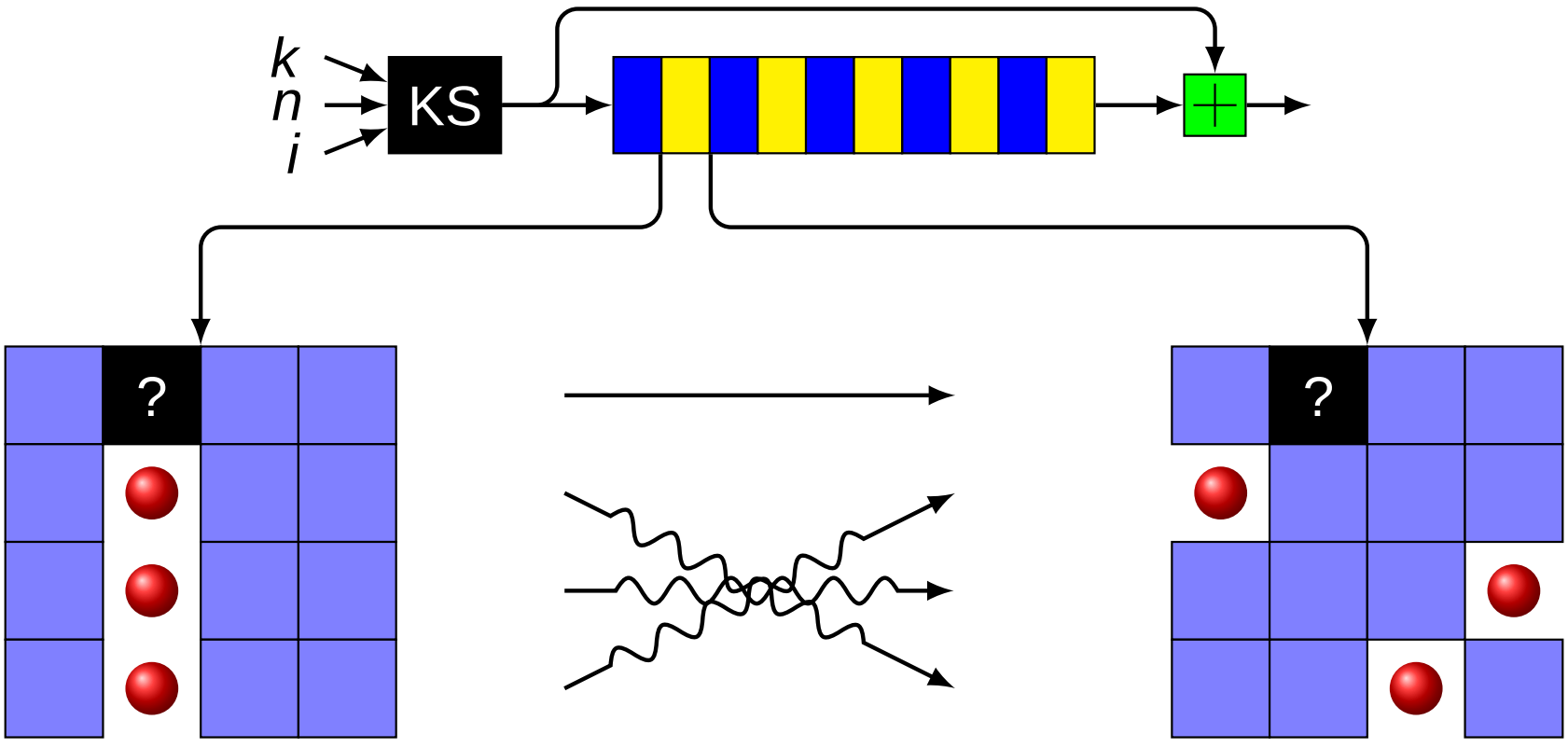
Differential characteristic



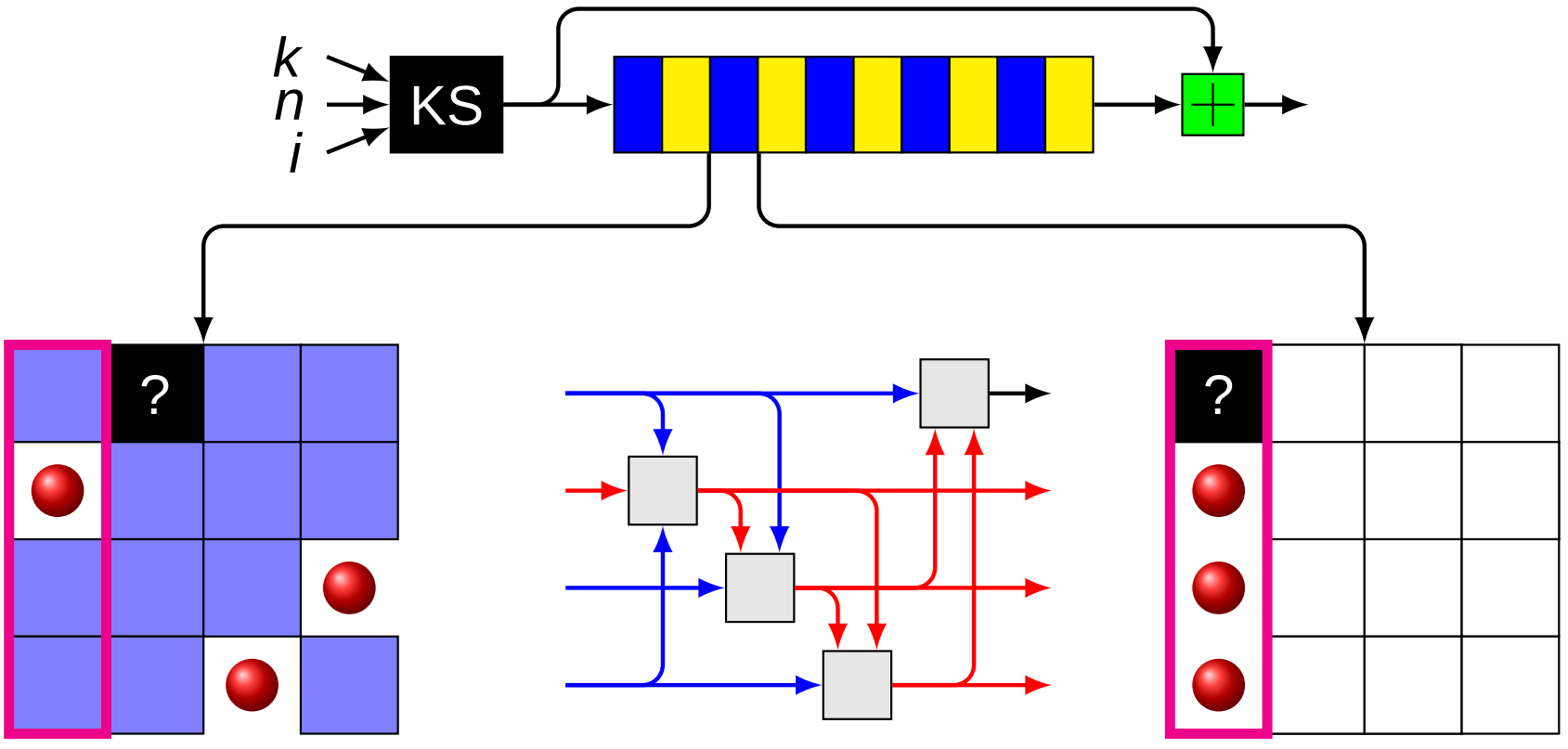
Differential characteristic



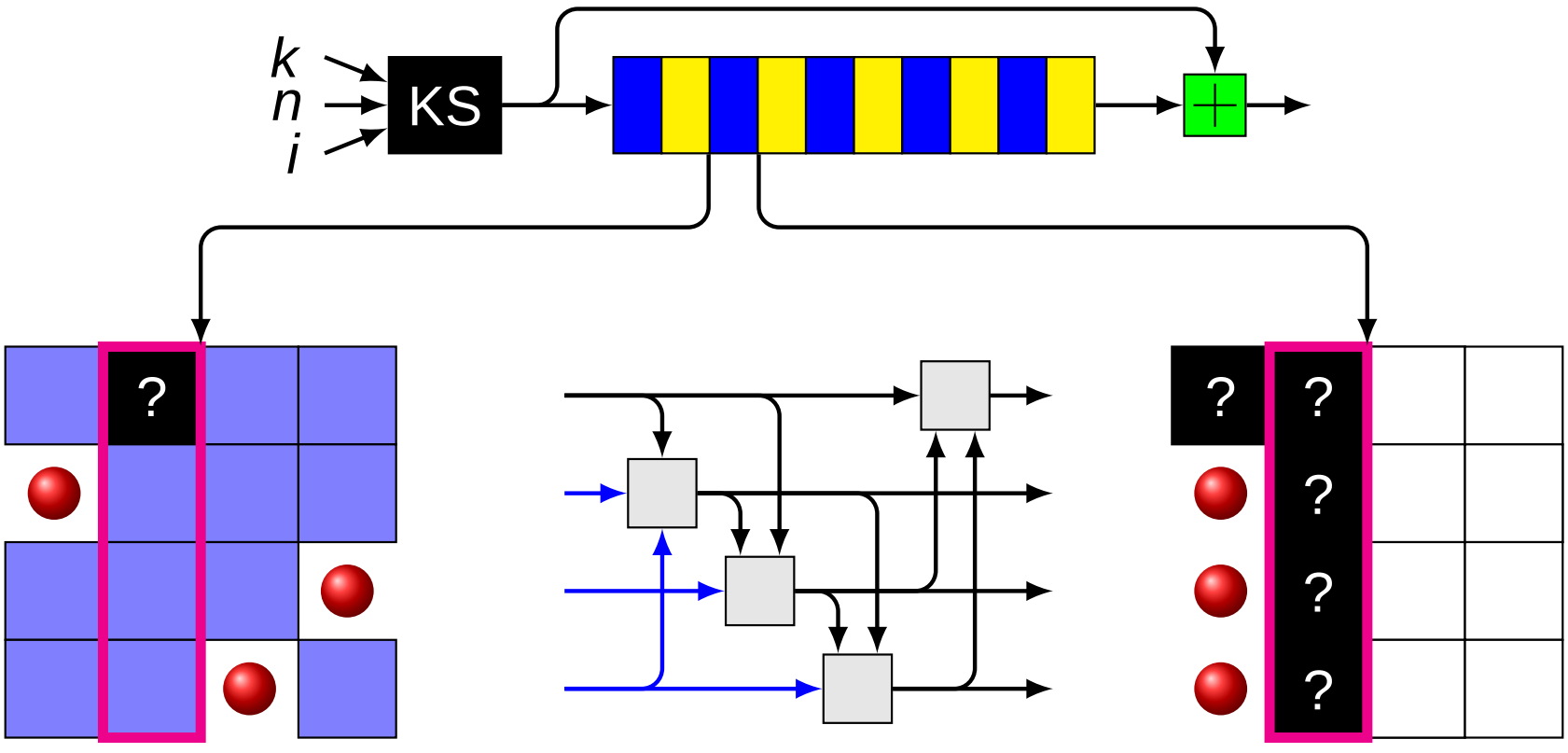
Differential characteristic



Differential characteristic



Differential characteristic



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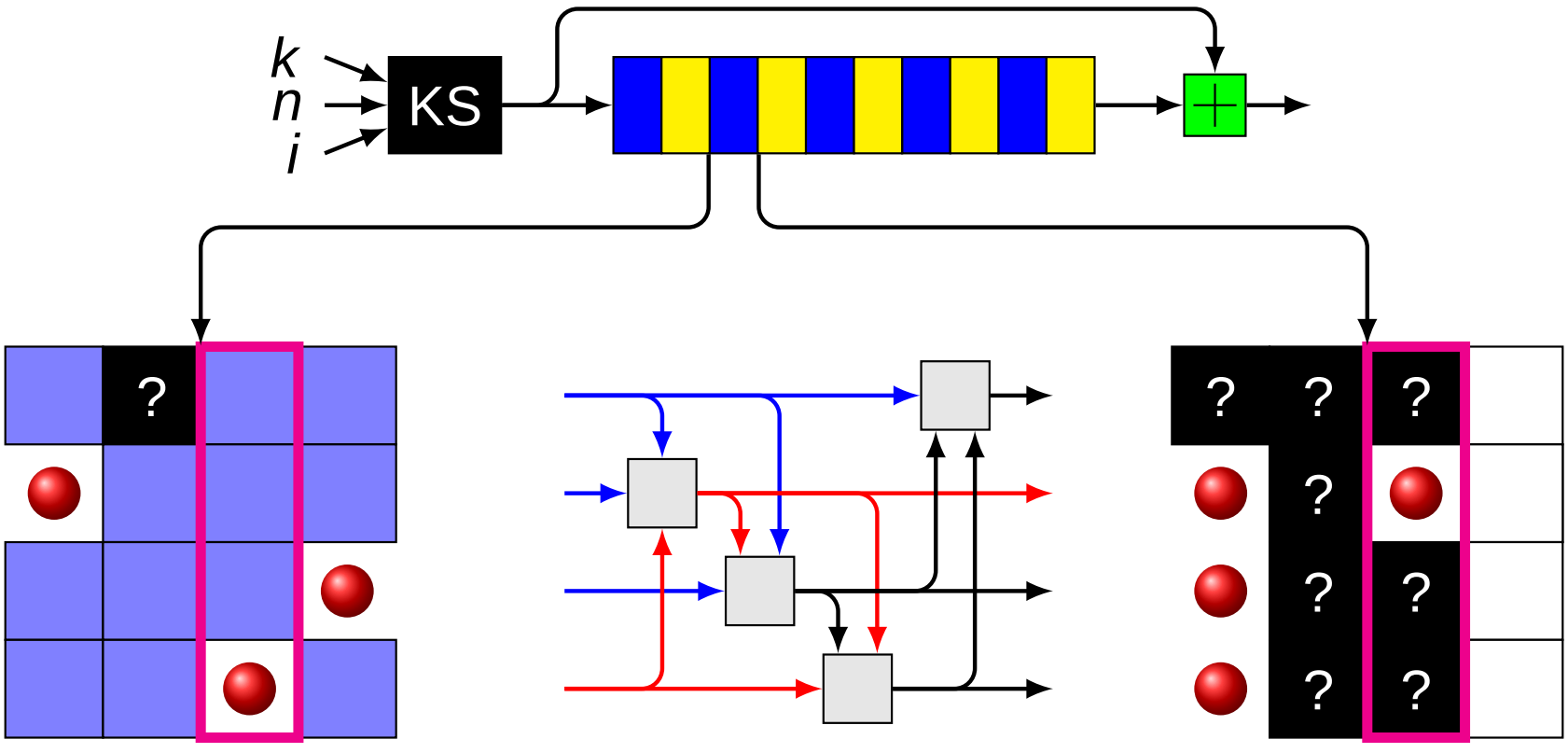
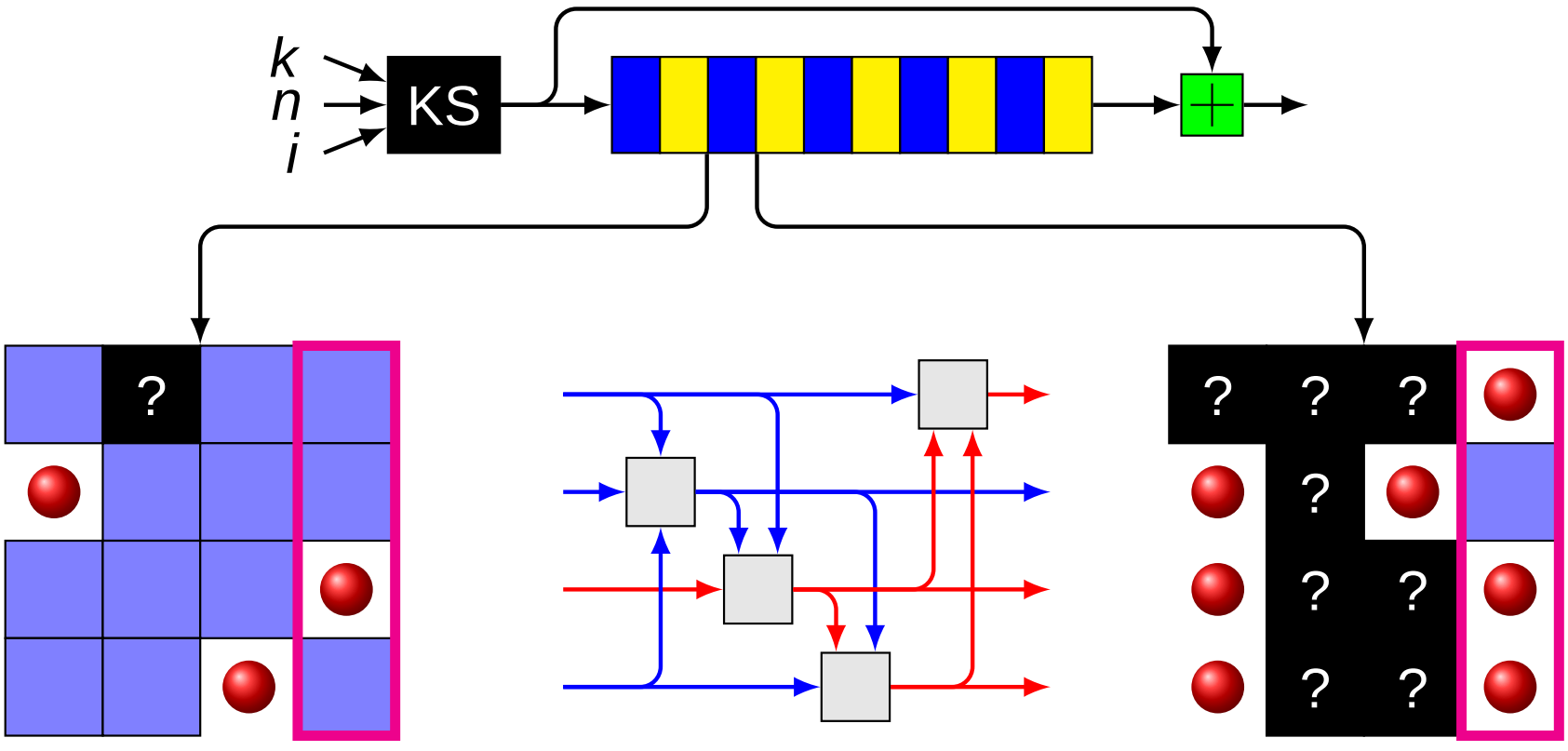


Differential characteristic



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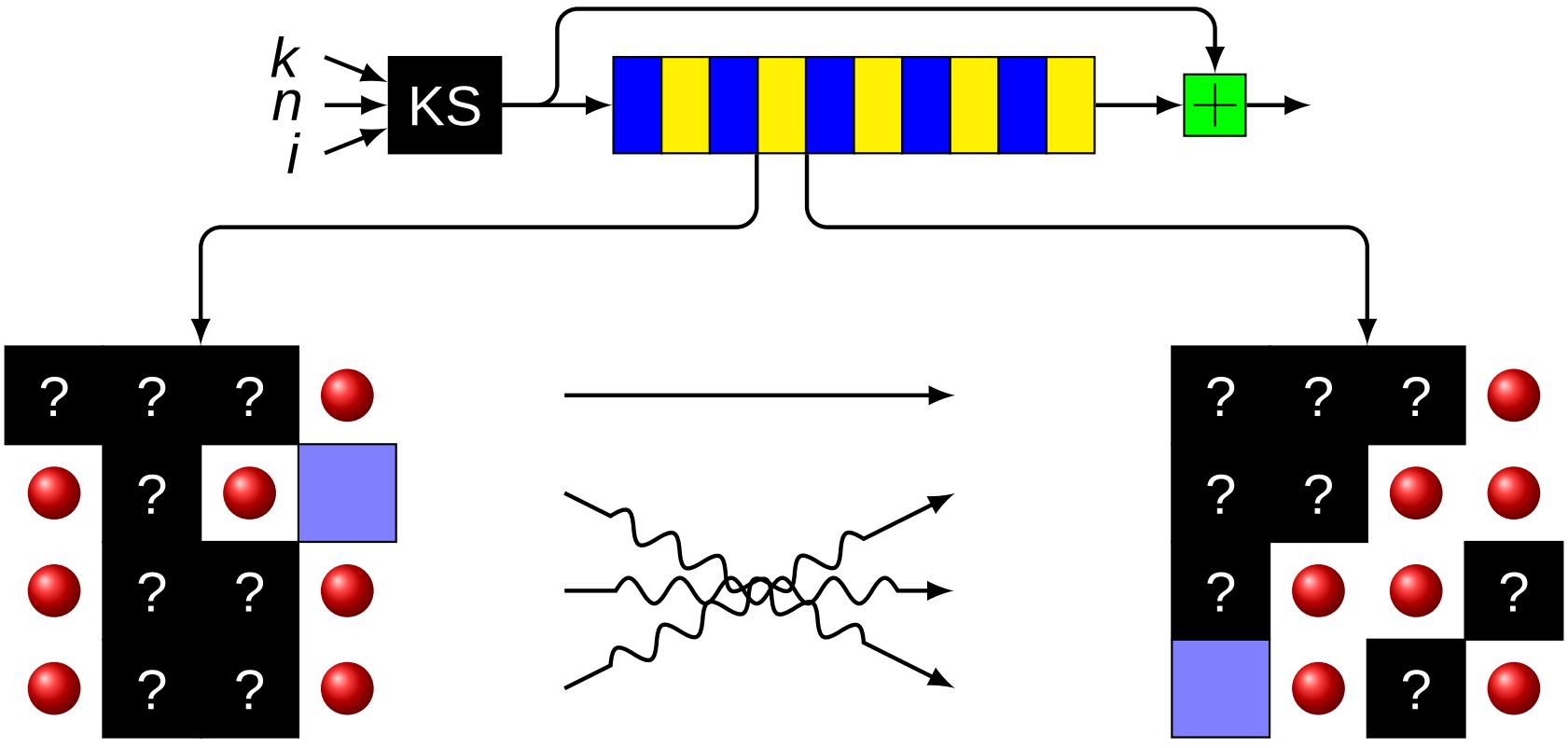

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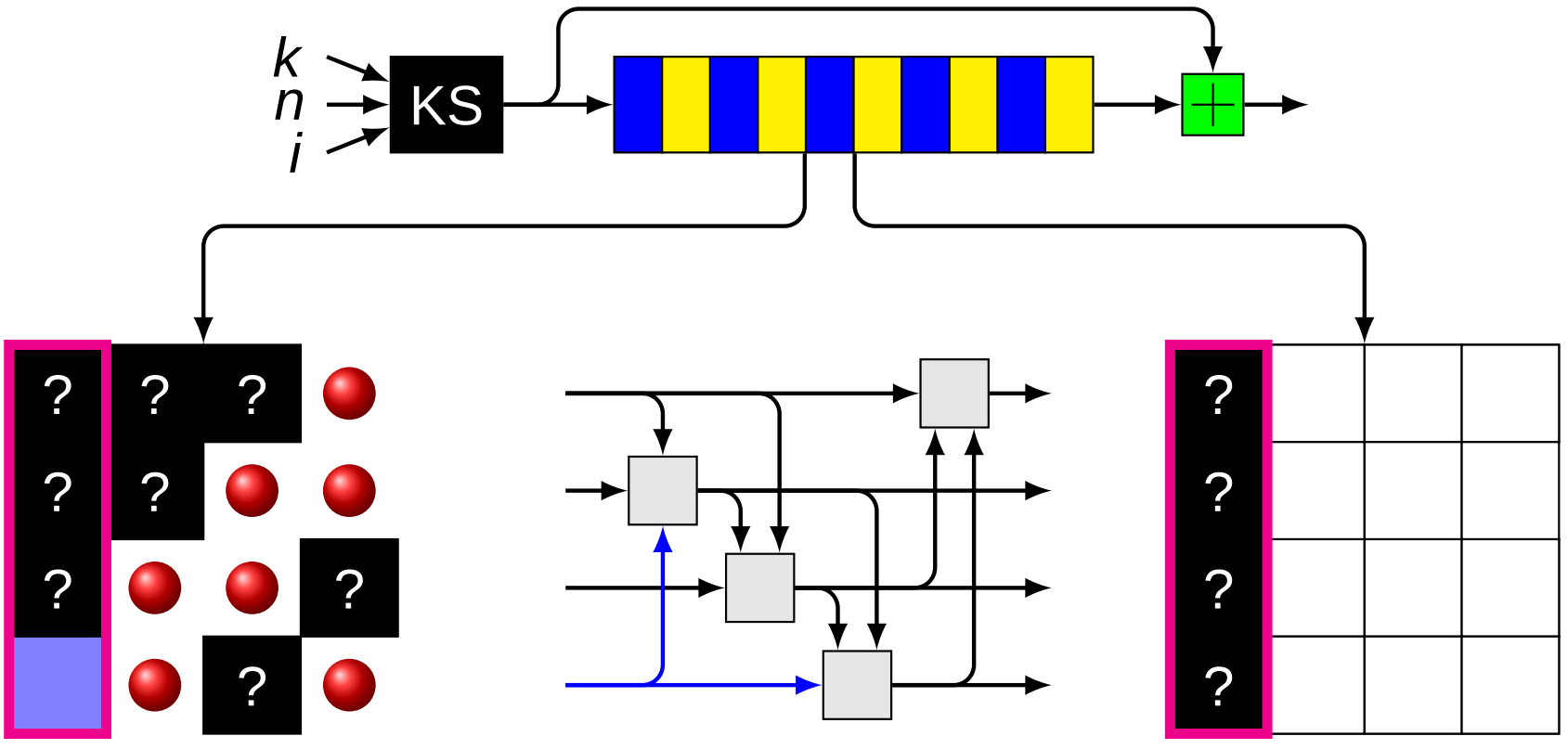

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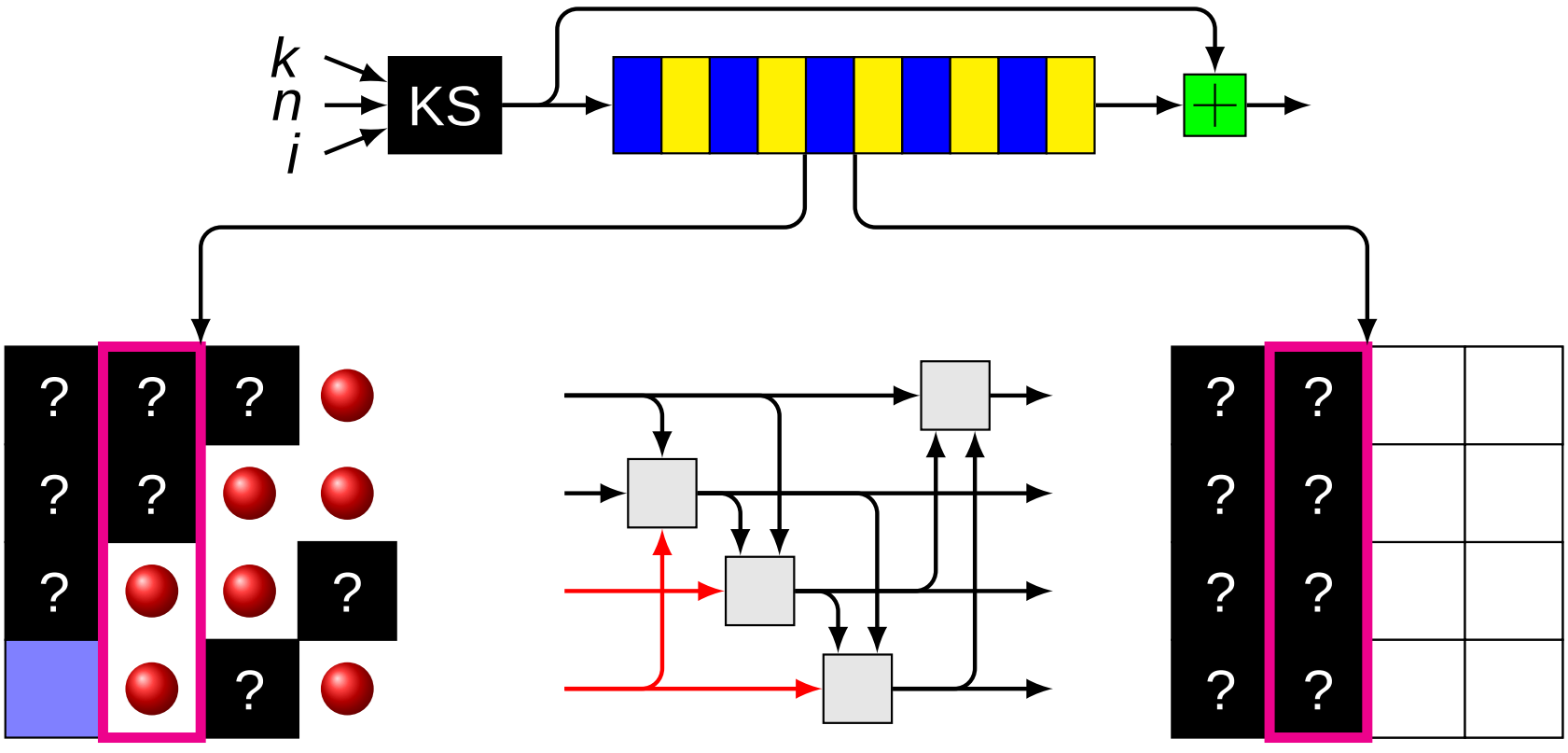

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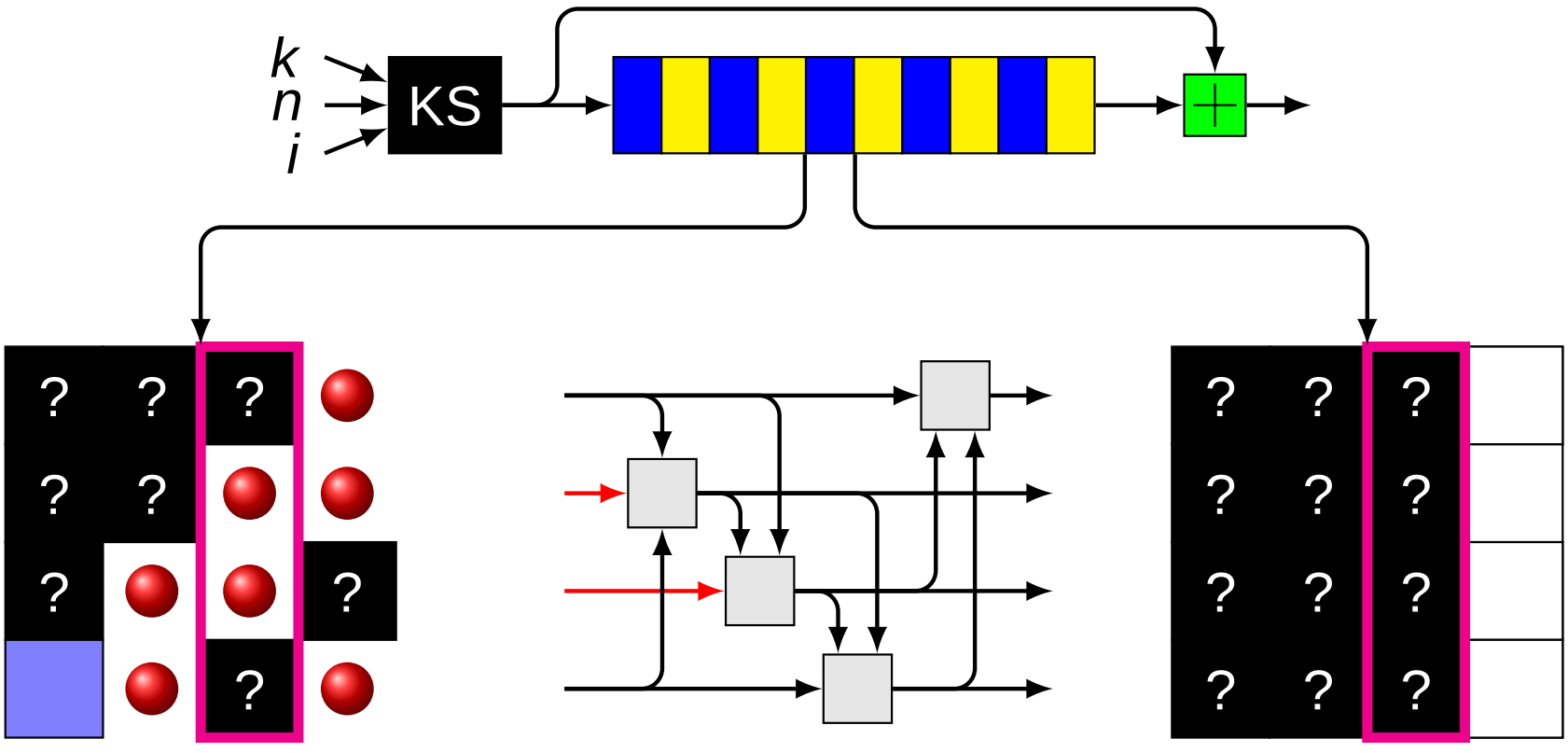

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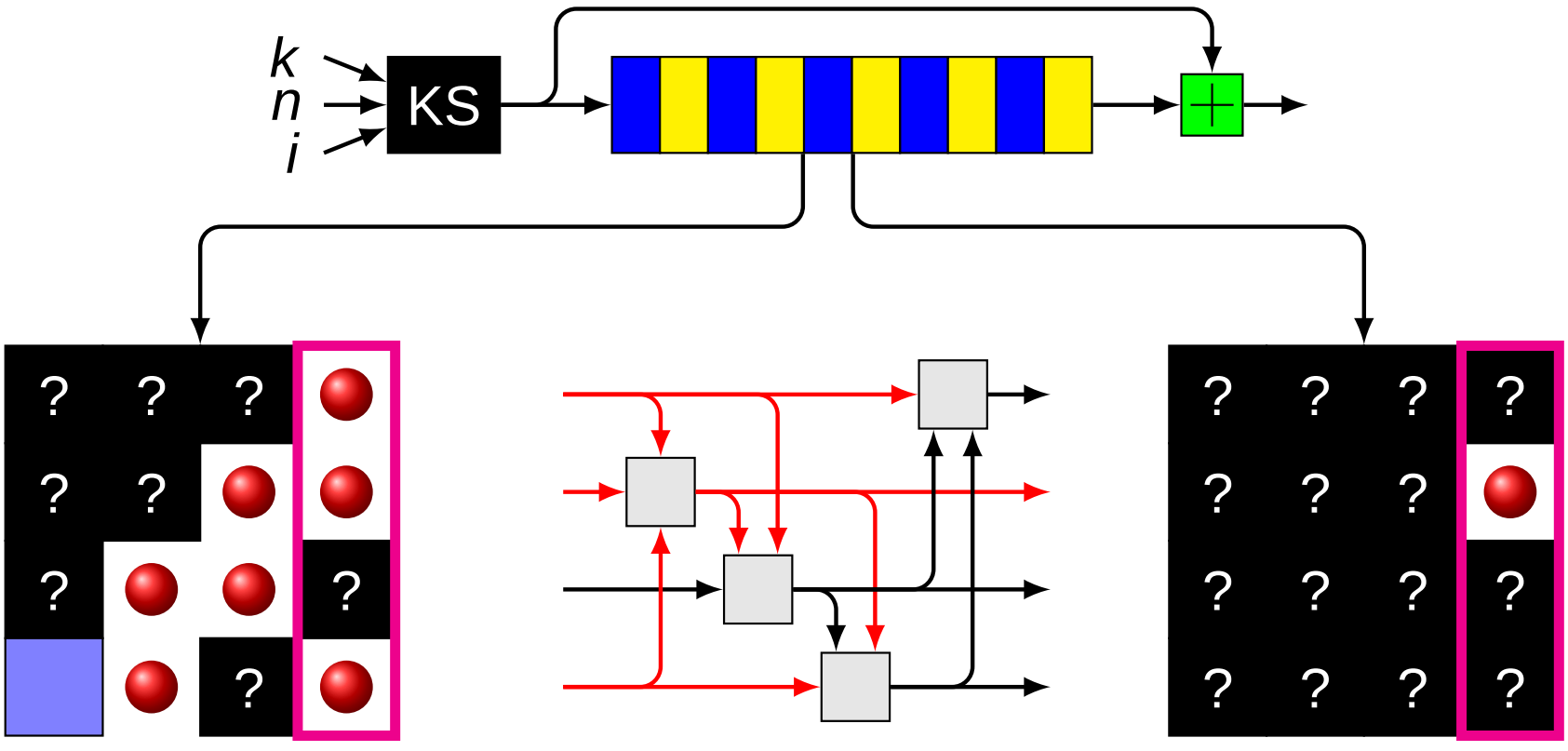

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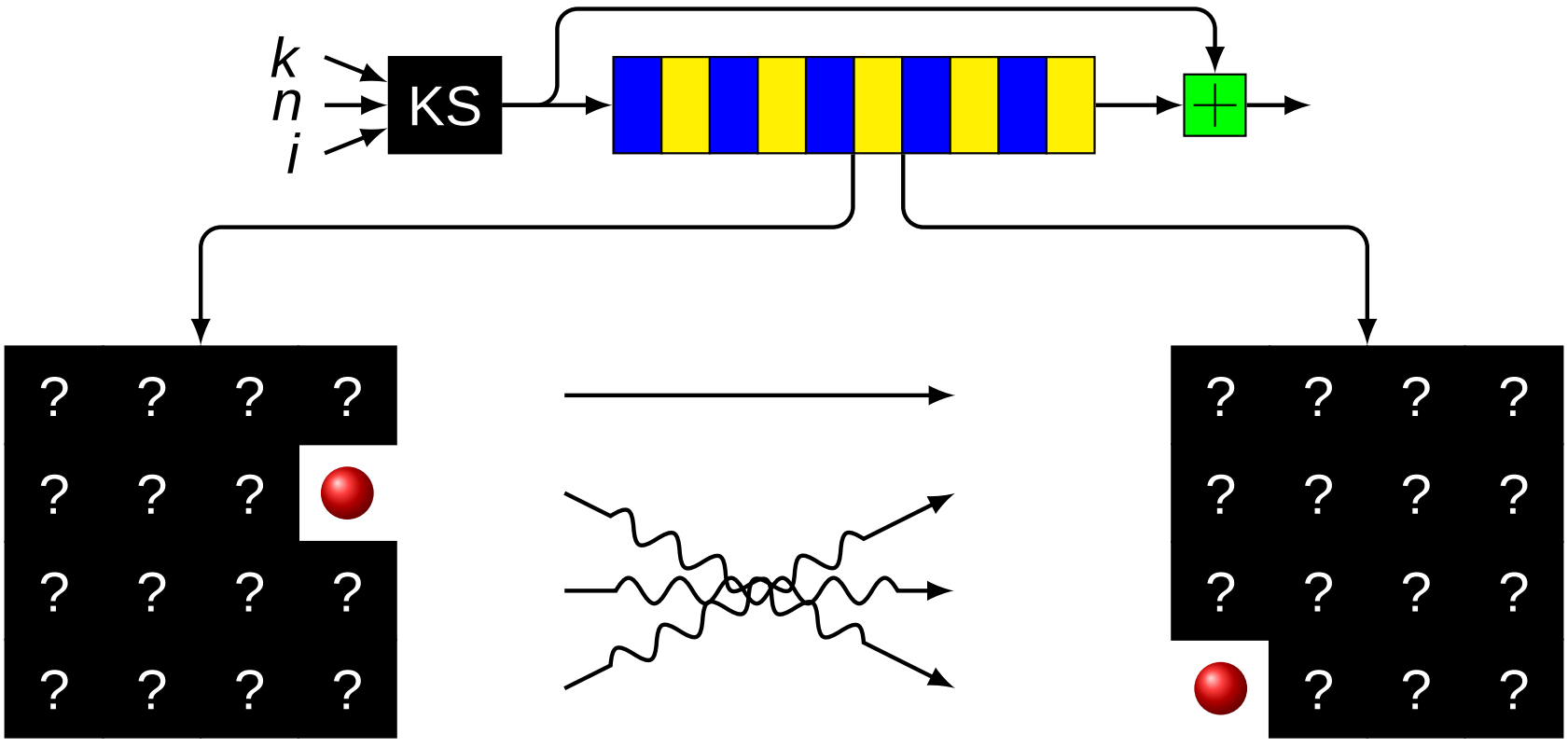
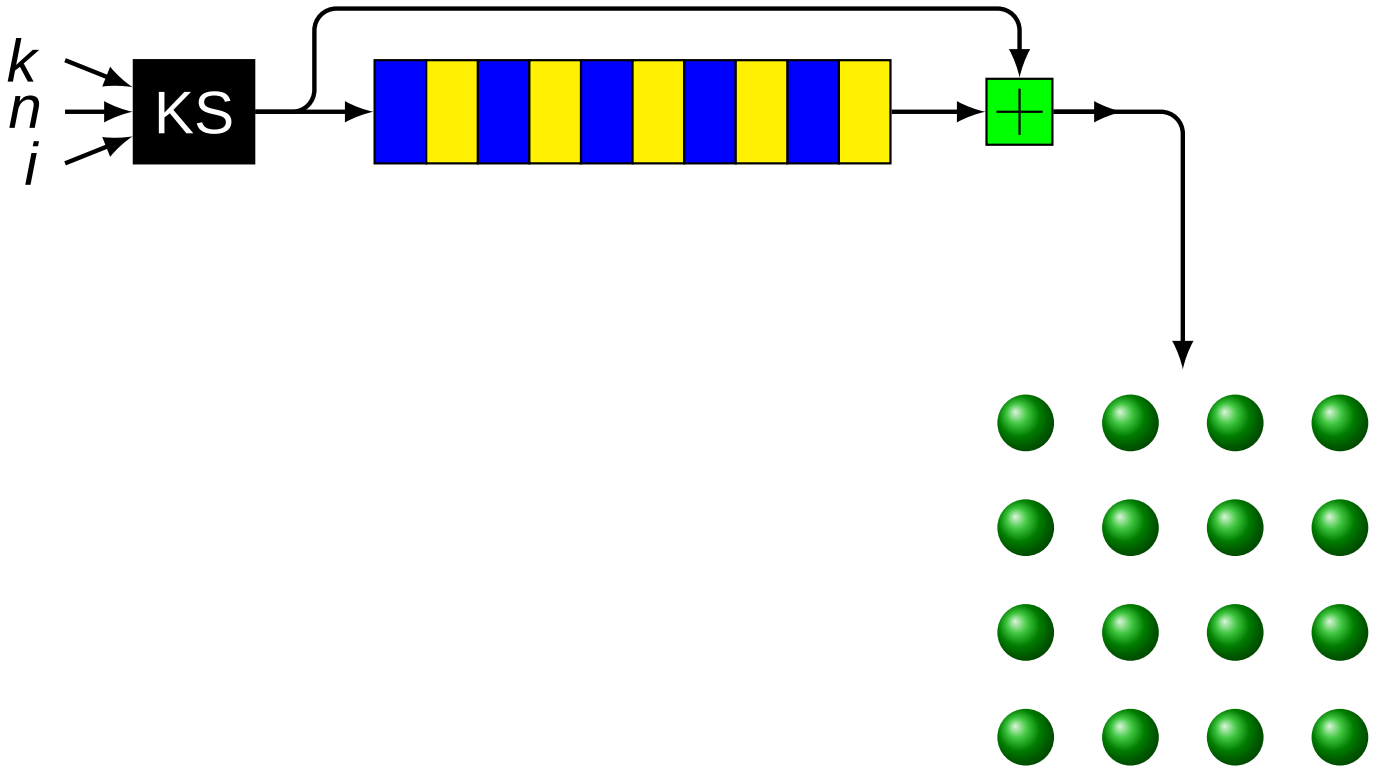


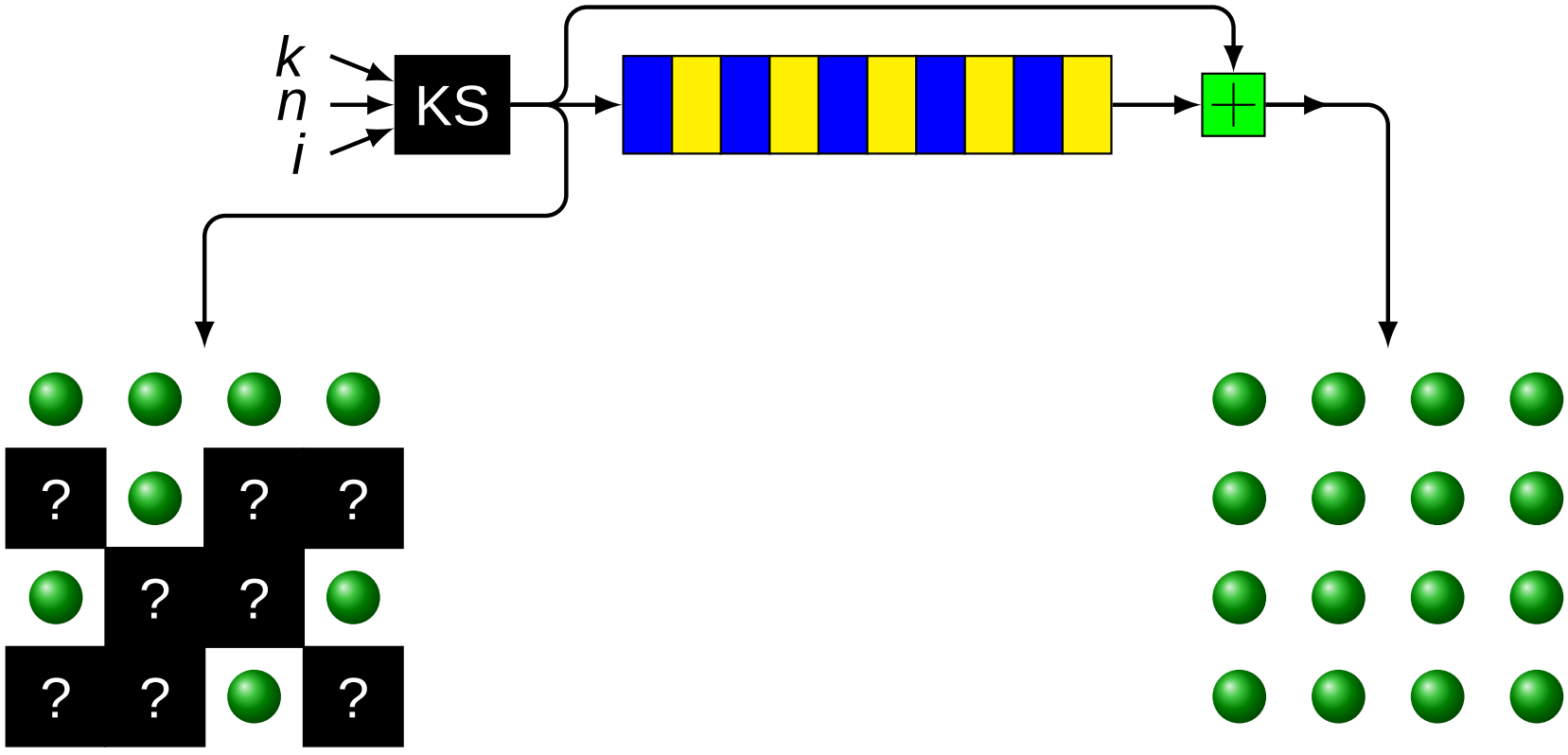
Increasing the probability

- Best characteristic: 2^{-12}
- Many differentials
- Many characteristics
- 1024 best differentials: ≈ 0.3

Inferring backwards



Inferring backwards



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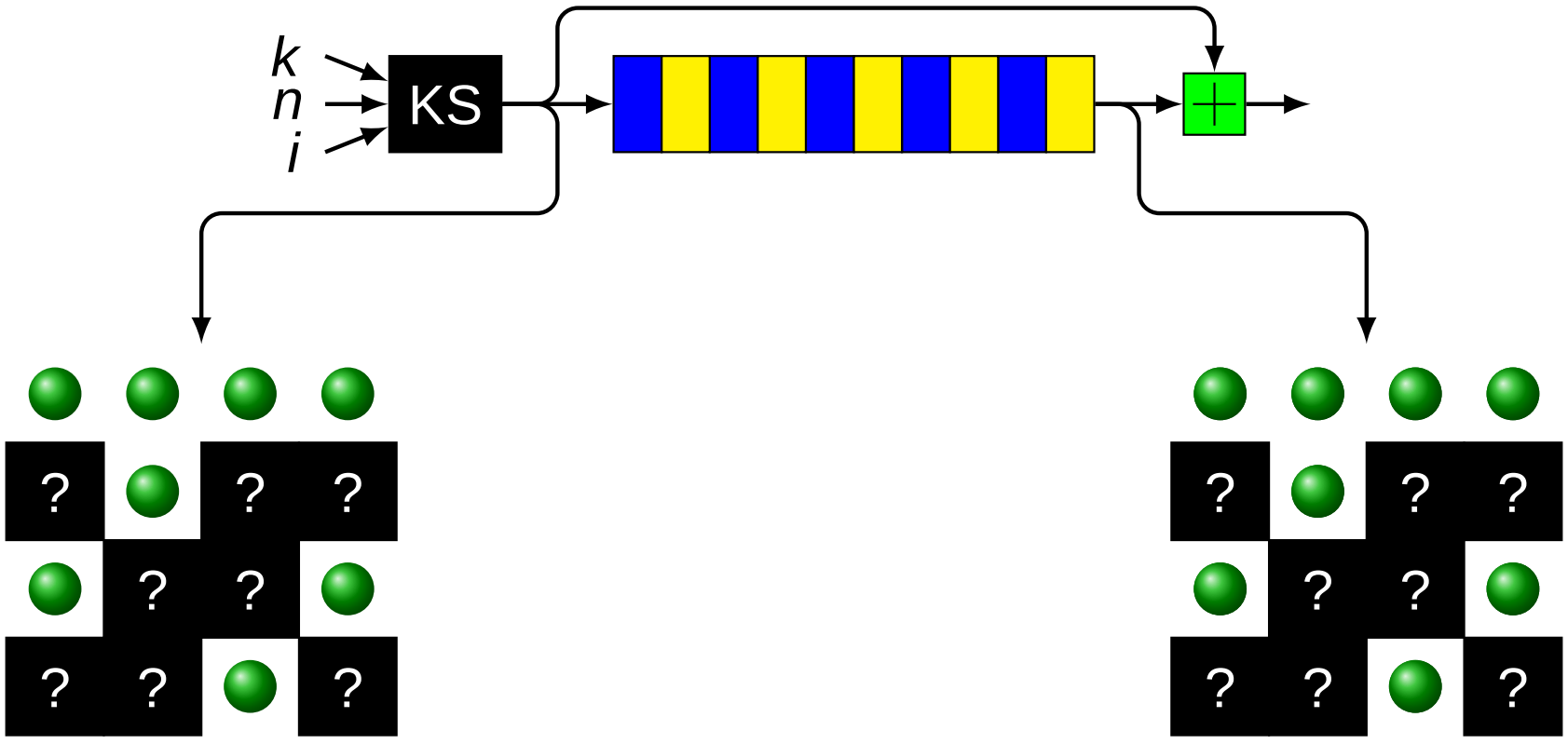

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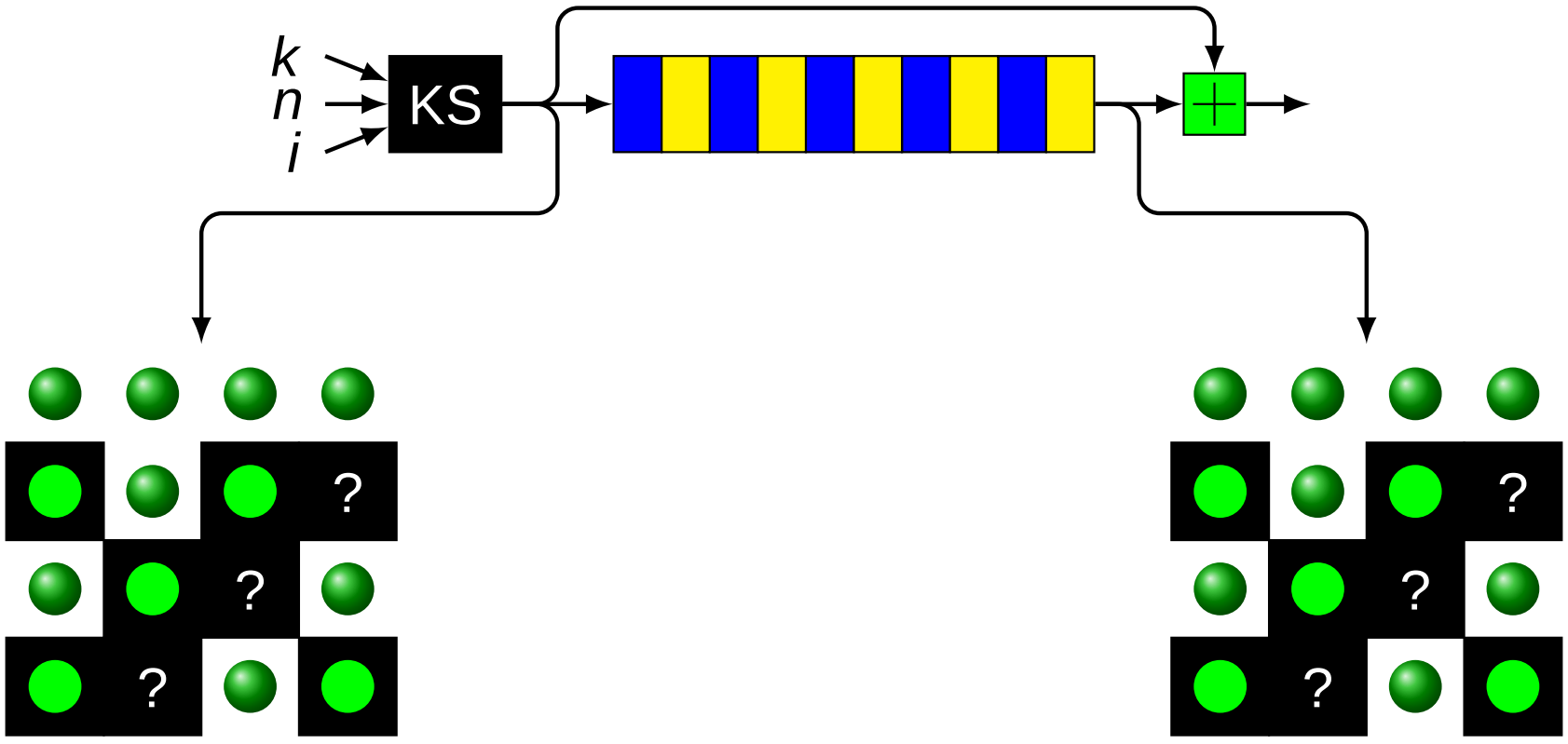

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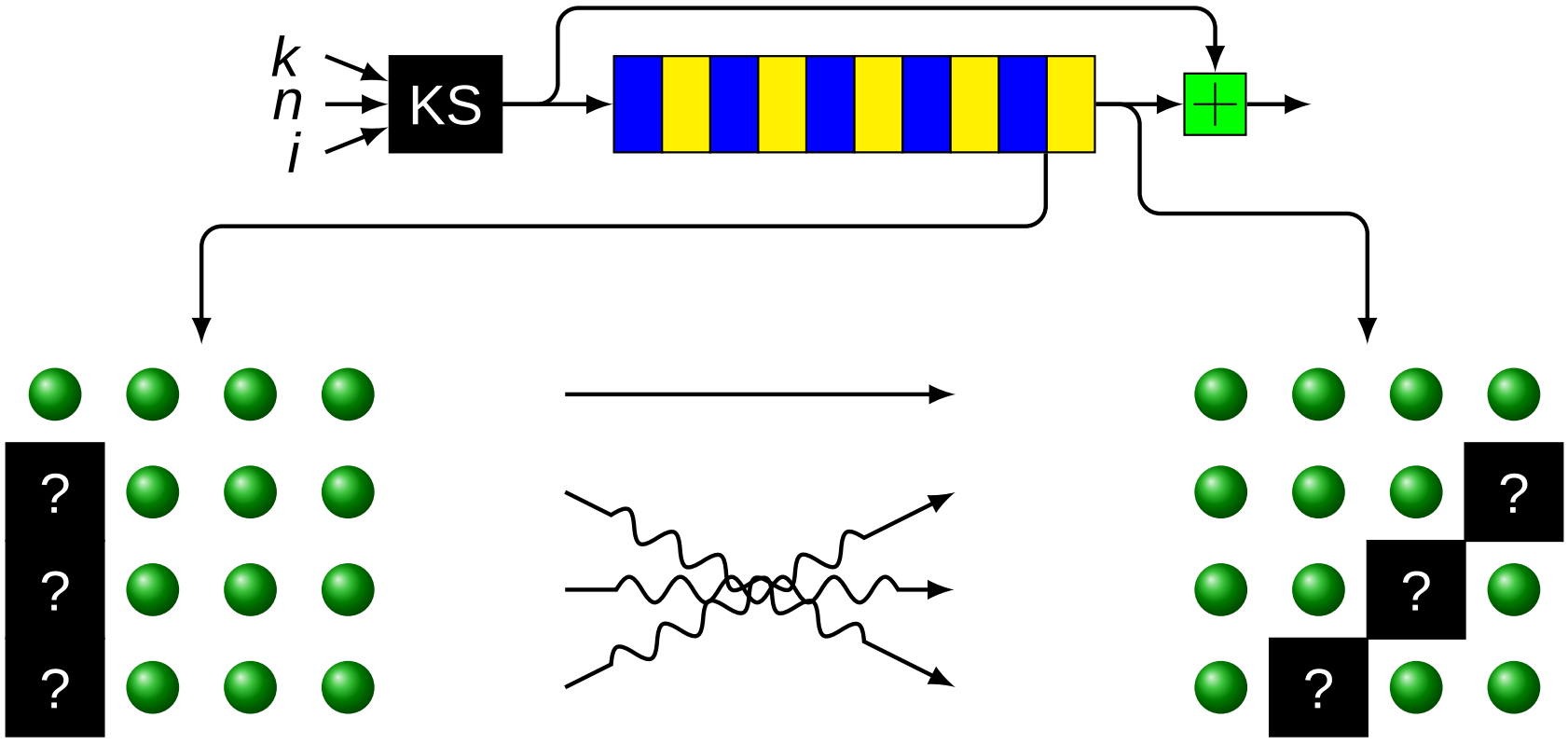

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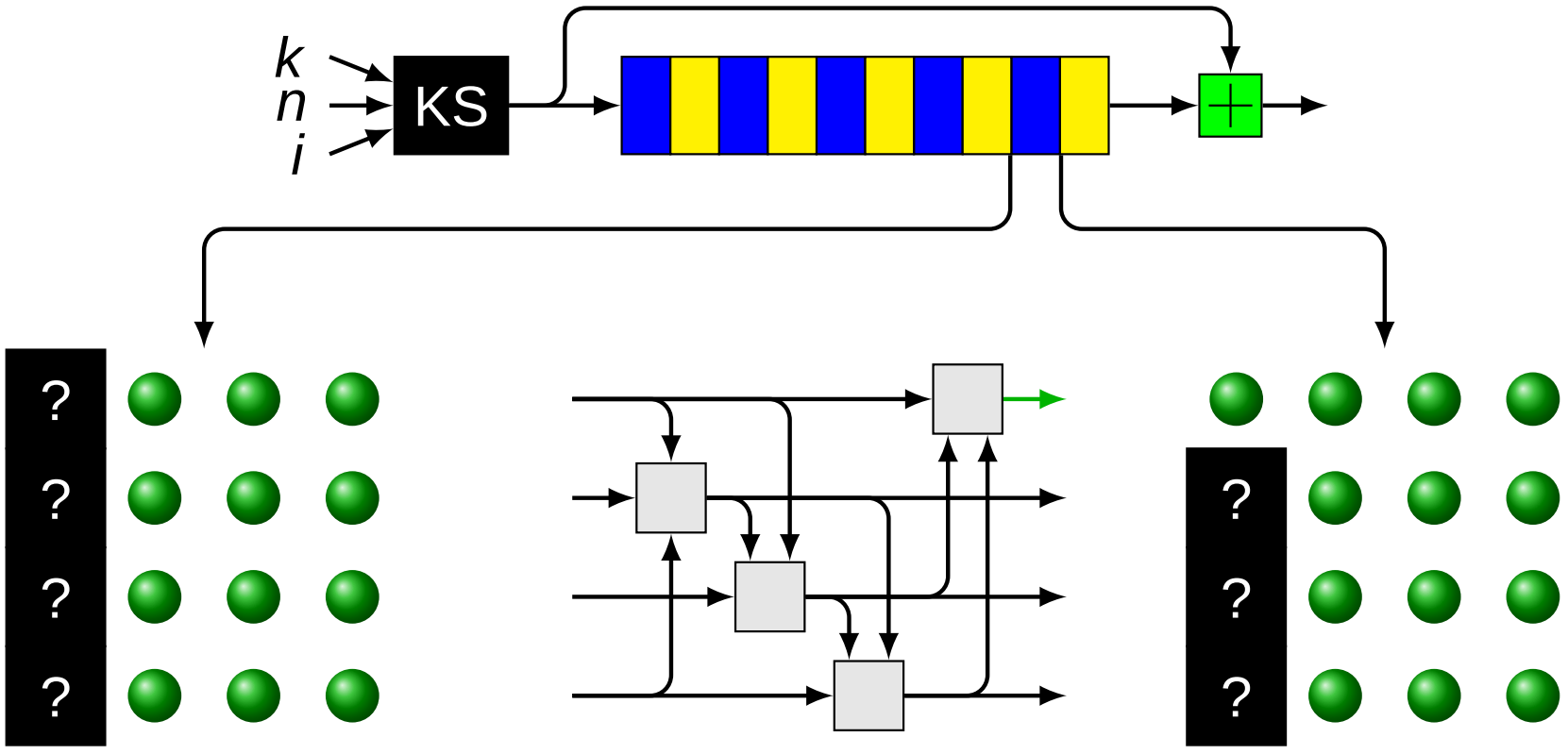

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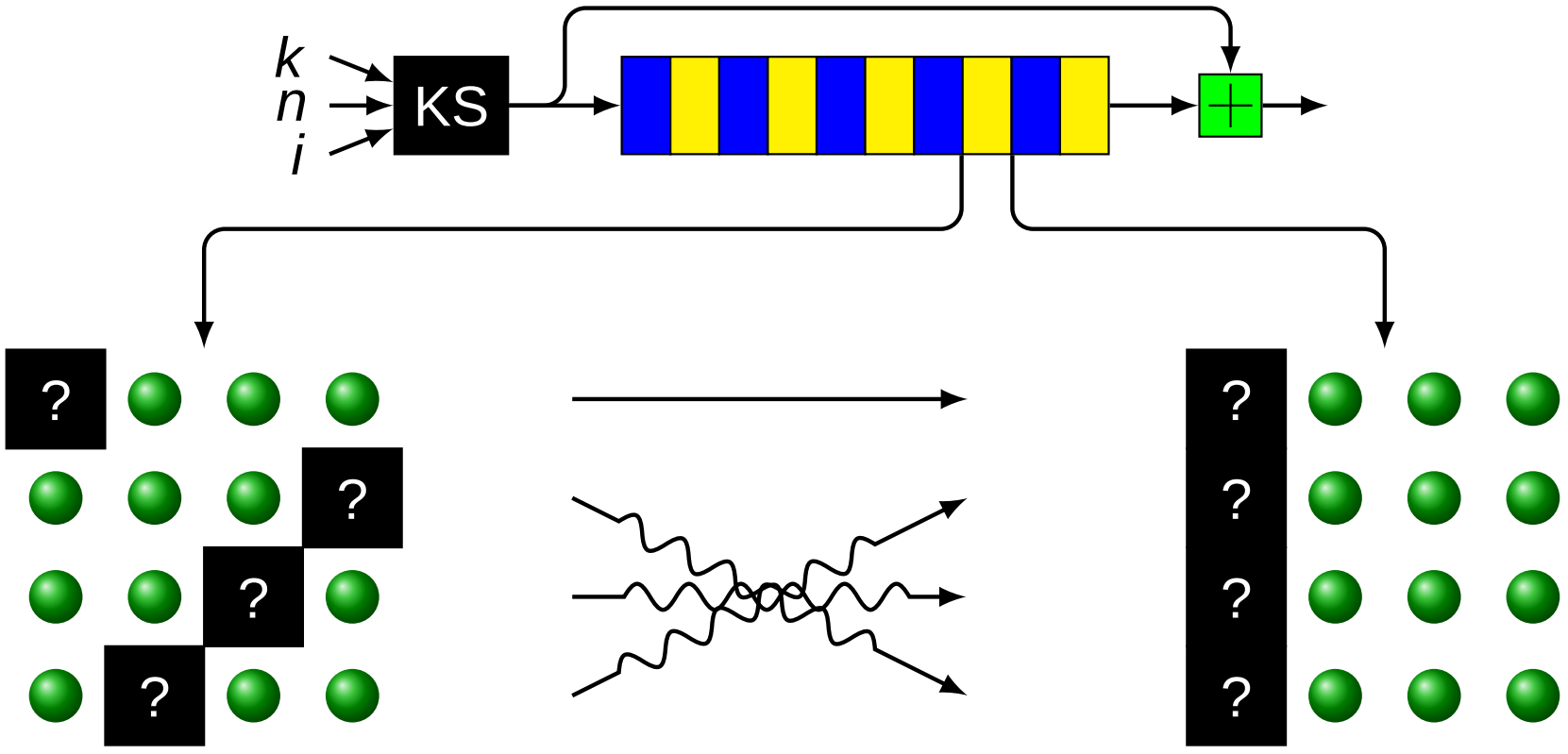

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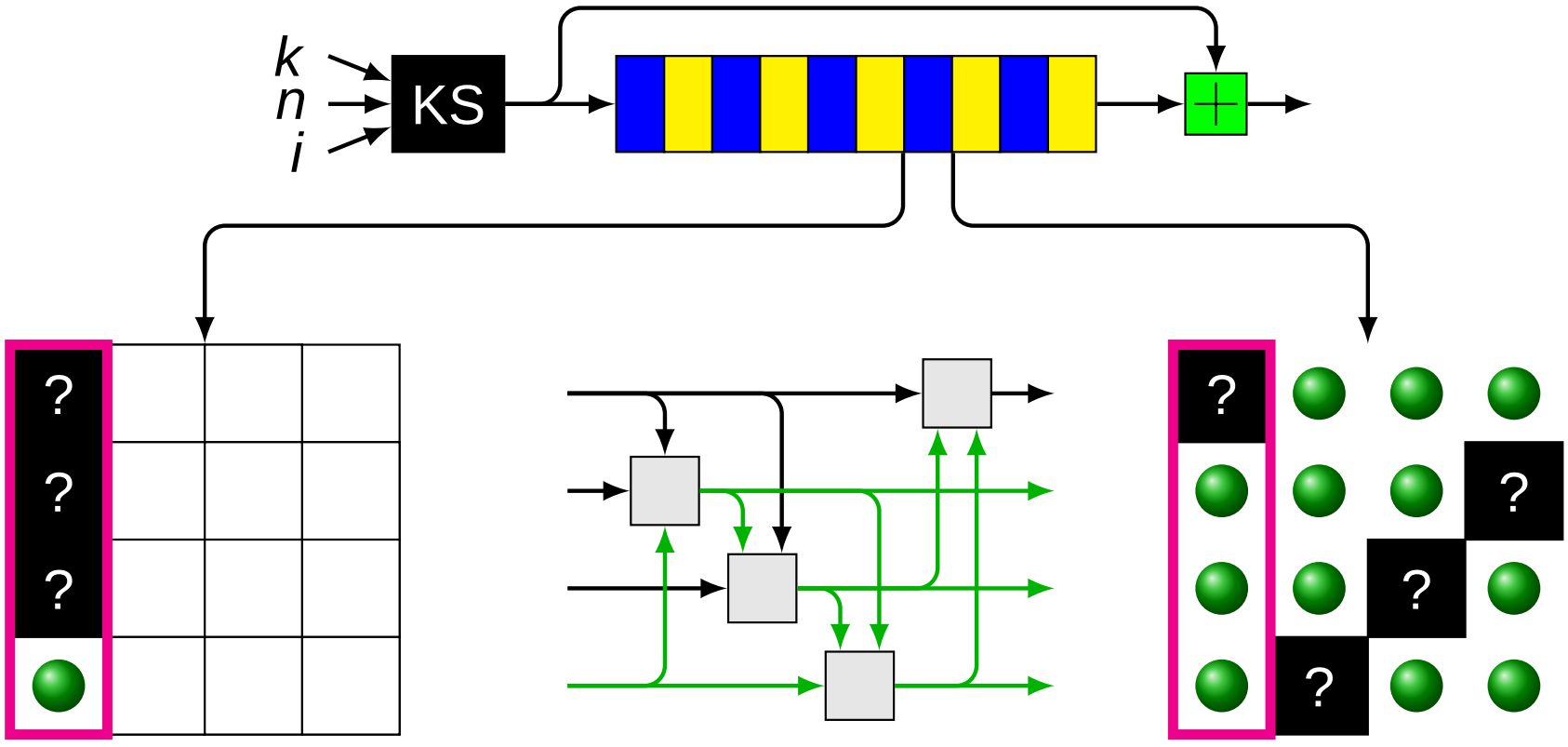

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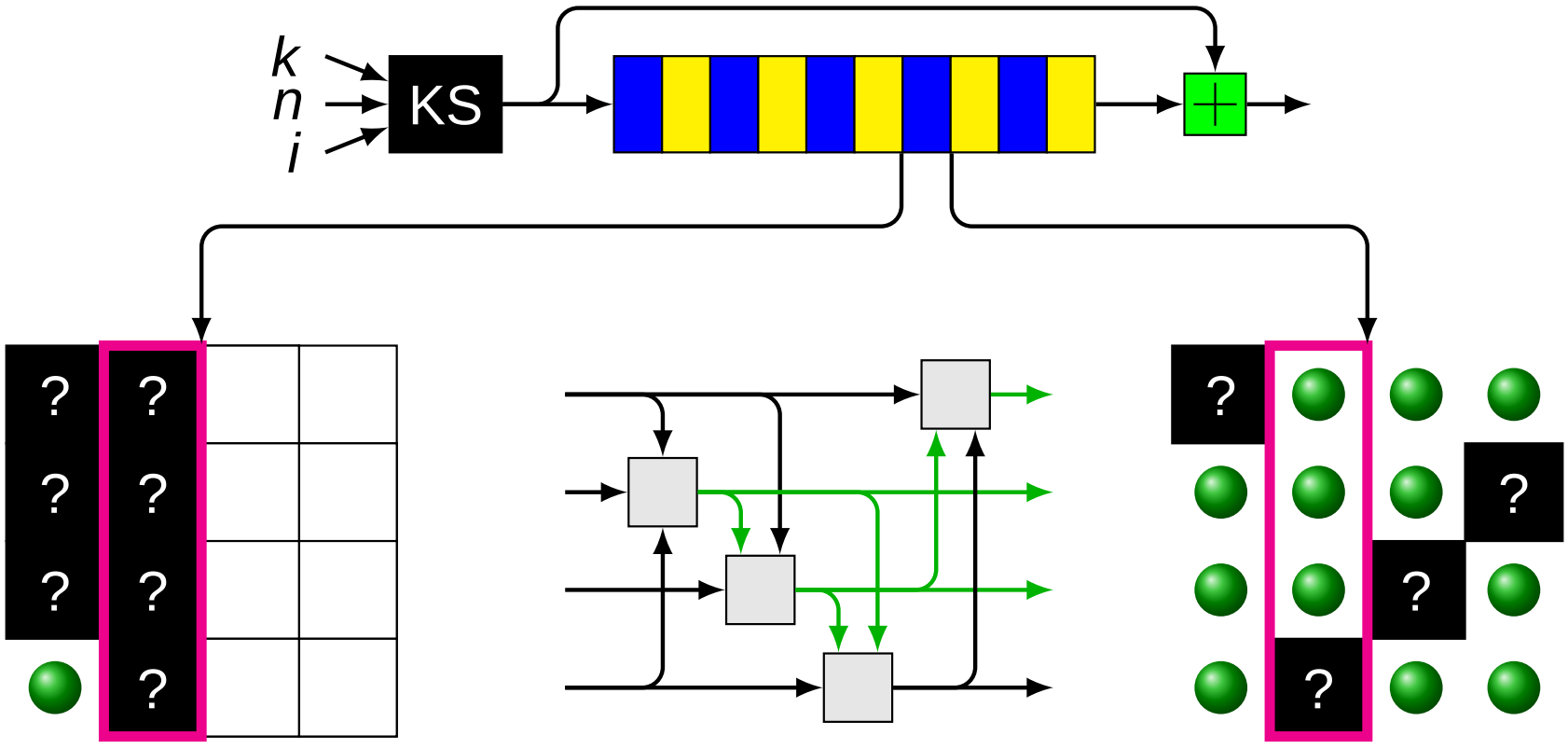

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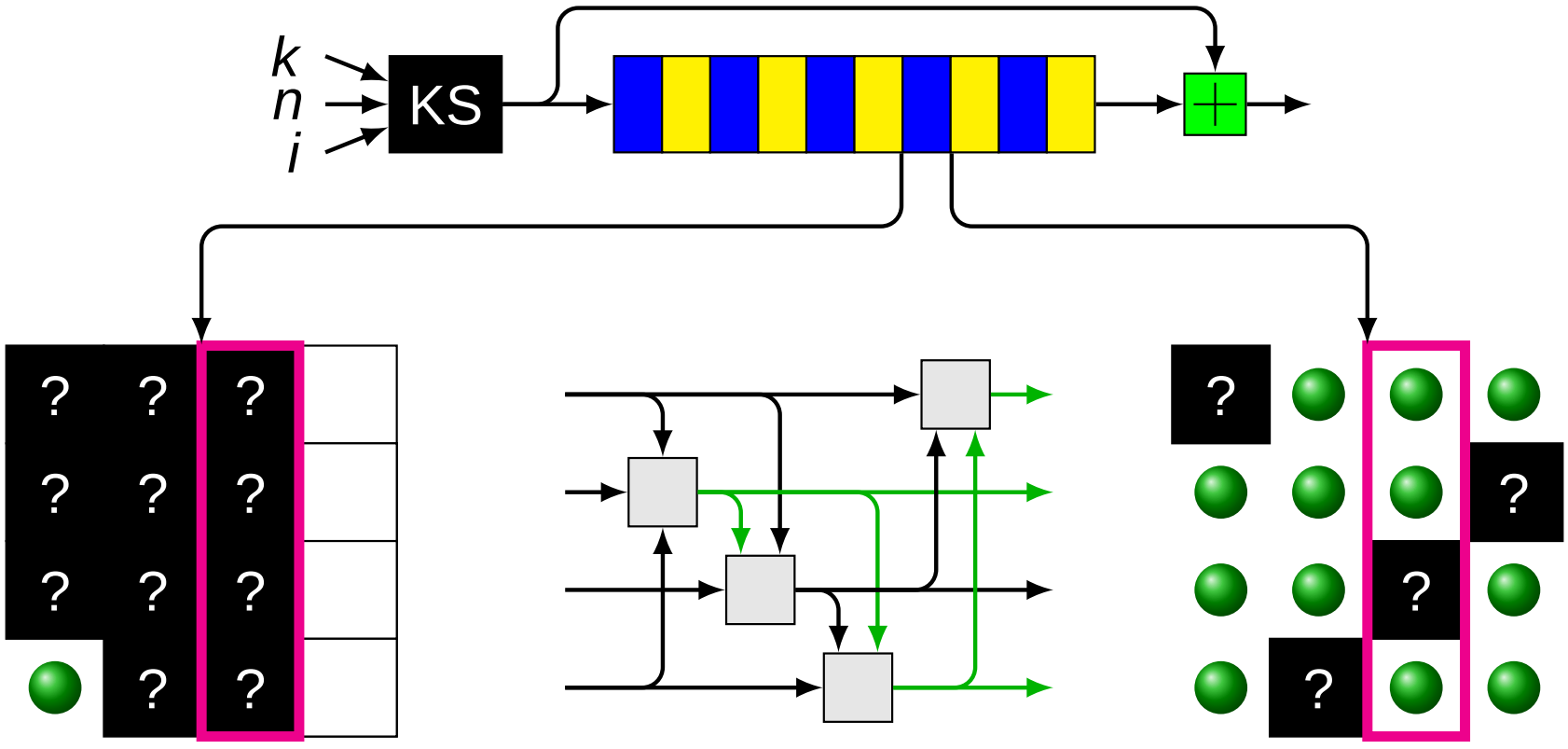

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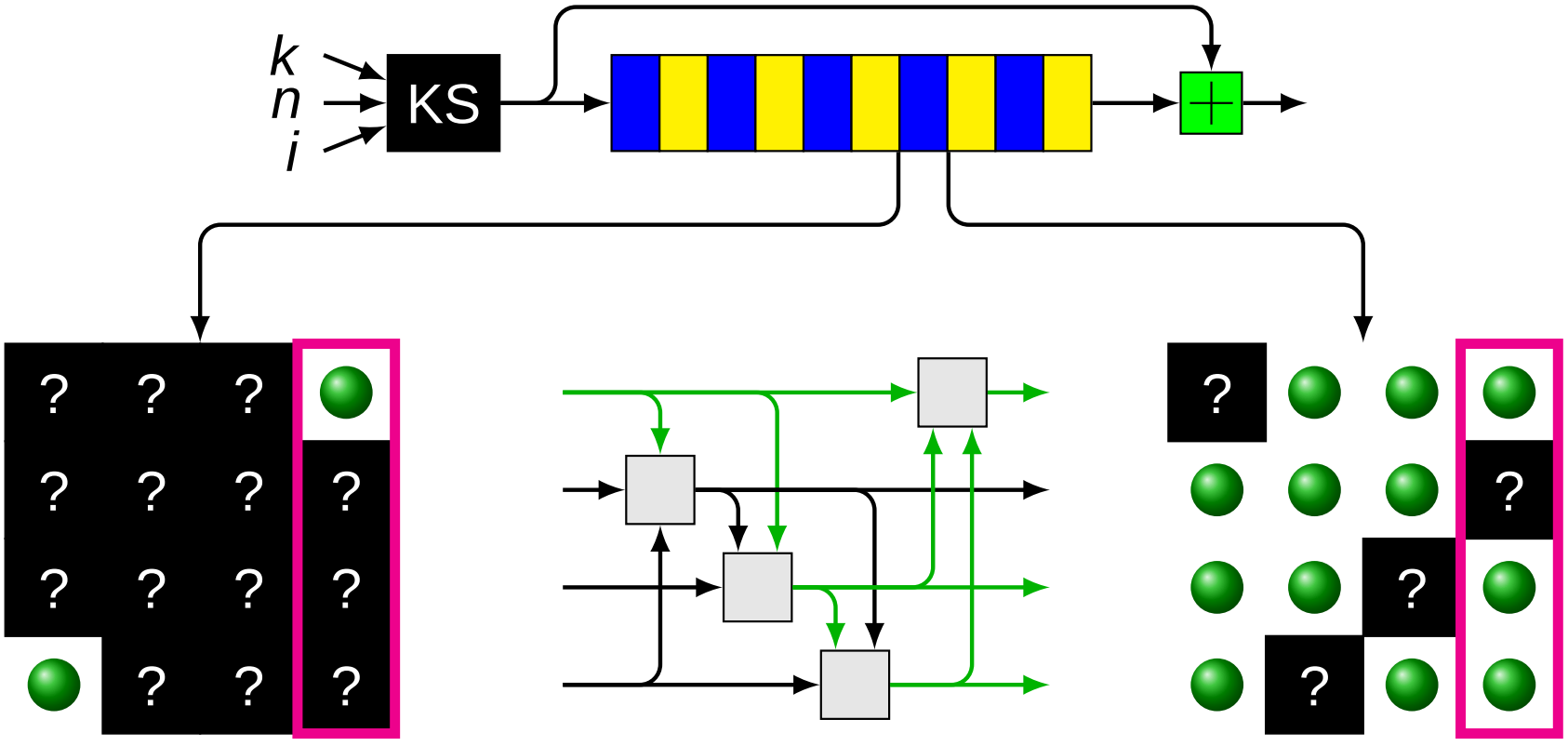

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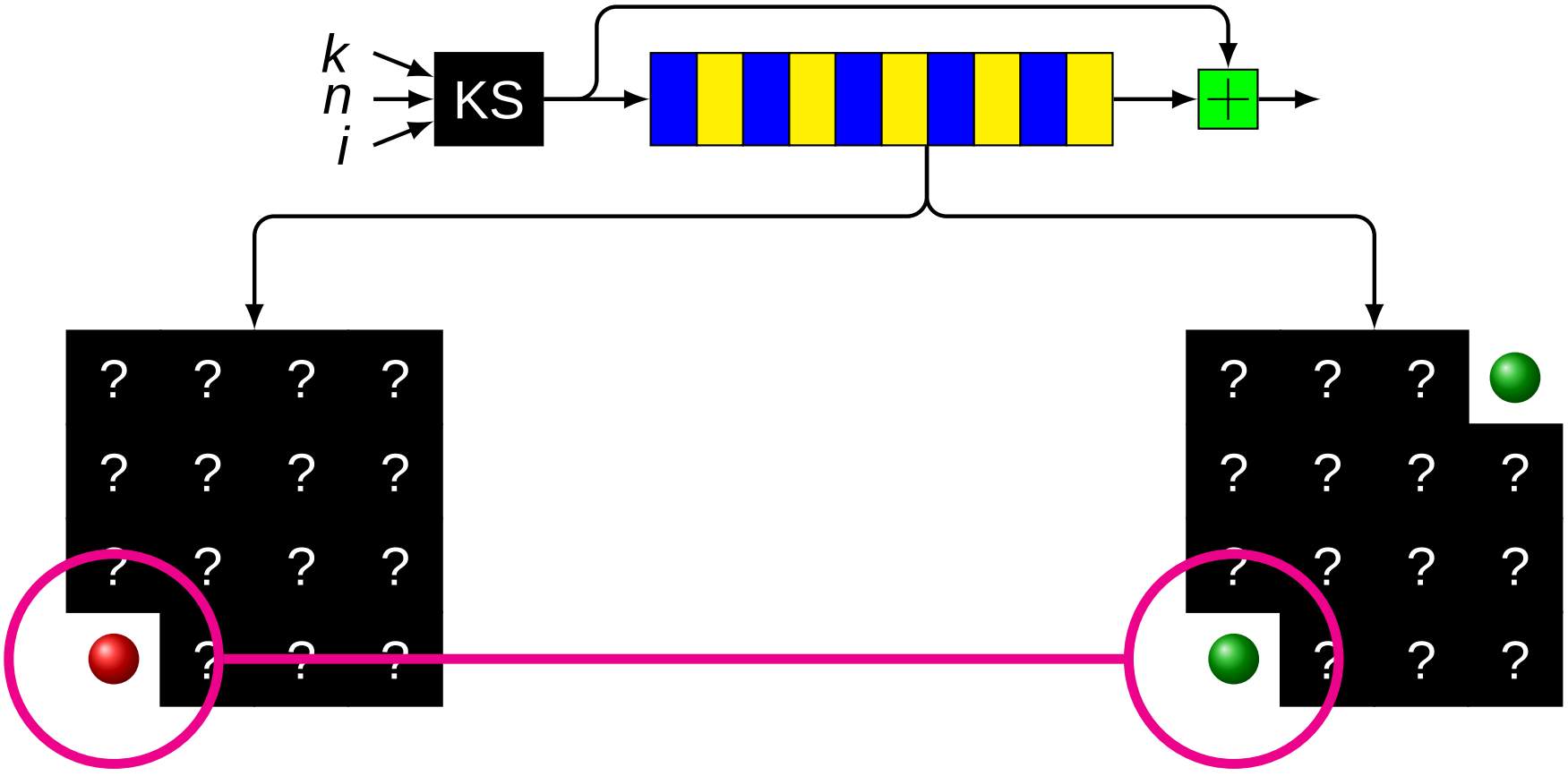

Work factor

- 32 plaintexts
- False positives: 2^{61}
- Work choosing candidates: 2^{165}
- Work discarding false positives: 2^{157}

Conclusions

- 5 rounds broken with 32 plaintext pairs and 2^{165} effort
- Differentials cluster in Salsa20
- Worth considering many differentials
- Cannot extend to full Salsa20

www.ciphergoth.org/crypto/salsa20