Cryptographic Hash Function
BLUE MIDNIGHT WISH

Presented by

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Outline

- Short history of BLUE MIDNIGHT WISH
- General characteristics of BLUE MIDNIGHT WISH
- Specific design characteristics
- SW/HW performance and memory requirements

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Short history of BLUE MIDNIGHT WISH

- Its predecessor is "**Turbo SHA-2**" hash function **http://eprint.iacr.org/2007/403** (authors Danilo Gligoroski and Svein Johan Knapskog),
  - Characteristics: design components from the SHA-2 family, more chaining variables, resistant against generic multi-block collision attacks, resistant against generic length extension attacks, 2 - 8 times faster than the original SHA-2, very fast diffusion and fast reaching the level of random Boolean function, has just 8 rounds in the iterative part (compared to 64 for SHA-256 and 80 for SHA-512).
- Vlastimil Klima: "**On Collisions of Hash Functions Turbo SHA-2**", **http://eprint.iacr.org/2008/003**
  - "***It follows that the only one remaining candidate from the hash family Turbo SHA is Turbo SHA-256 (and Turbo SHA-512) with 8 rounds. The original security reserve of 6 round has been lost.***"

Short history of BLUE MIDNIGHT WISH (cont.)

- Gligoroski and Klima started more intensively to investigate and improve Turbo SHA-2 hash function (in spring 2008).
- They put a working name of the new hash function: **“Blue Wish”**
- **BUT …**

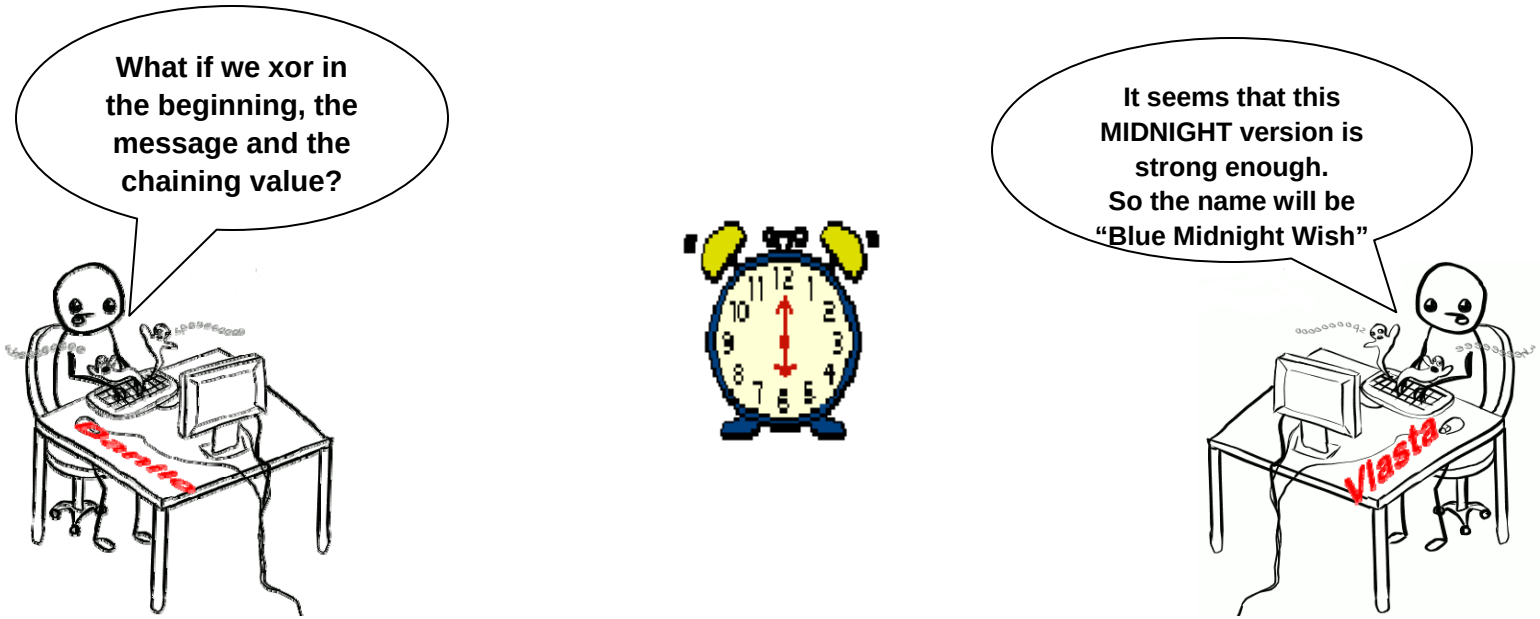
Short history of

BLUE MIDNIGHT WISH (cont.)

BLUE WISH ® is registered trade mark for towels.

Short history of BLUE MIDNIGHT WISH (cont.)

- In one occasion working very late (all night), exchanging emails, breaking and fixing numerous versions, one version that was produced after the **midnight** had the best characteristics that satisfied the designers.



BLUE MIDNIGHT WISH **was defined**

Short history of BLUE MIDNIGHT WISH (cont.)

- Additionally, the following contributors joined the BLUE MIDNIGHT WISH team:
  - Svein Johan Knapskog (coordinating the synergy in the team, general comments and suggestions for improvements, proofreading)
  - Mohamed El-Hadedy (VHDL implementation)
  - Jørn Amundsen (Big-endian and endian-neutral implementation, suggestions for improvements)
  - Stig Frode Mjølsnes (contributed to an 8-bit implementation)

General design characteristics for BLUE MIDNIGHT WISH

Algorithm: BLUE MIDNIGHT WISH

Input: Message M of length l bits, and the message digest size n.

Output: A message digest *Hash*, that is n bits long.

1. Preprocessing
   (a) Pad the message M.
   (b) Parse the padded message into N, m-bit message blocks, $M^{(1)}, M^{(2)}, \ldots, M^{(N)}$.
   (c) Set the initial value of the double pipe $H^{(0)}$.
2. Hash computation

   For $i = 1$ to N

   {

   $Q_a^{(i)} = f_0(M^{(i)}, H^{(i-1)})$;

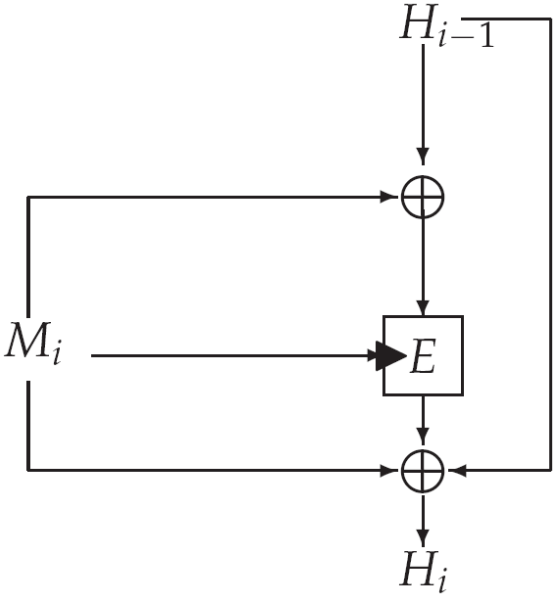
   $Q_b^{(i)} = f_1(M^{(i)}, Q_a^{(i)})$;

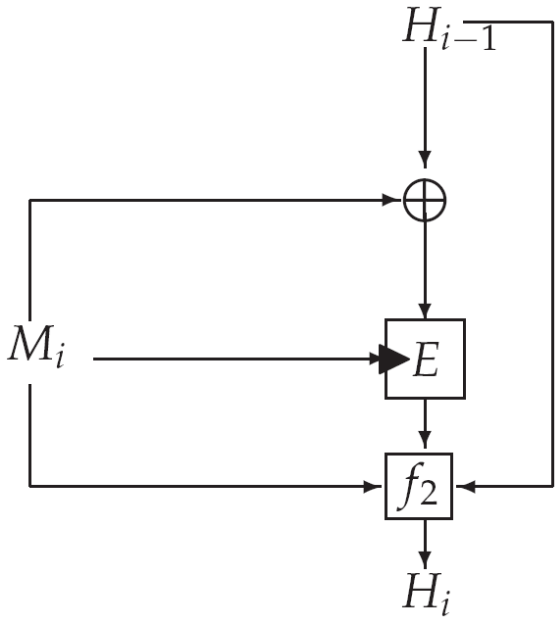
   $H^{(i)} = f_2(M^{(i)}, Q_a^{(i)}, Q_b^{(i)})$;

   }

3. *Hash* =Take_n_Least_Significant_Bits($H^{(N)}$).

Compression function for BLUE MIDNIGHT WISH





Preneel-Govaerts-Vandewalle scheme Nr. 6 (or PGV6):

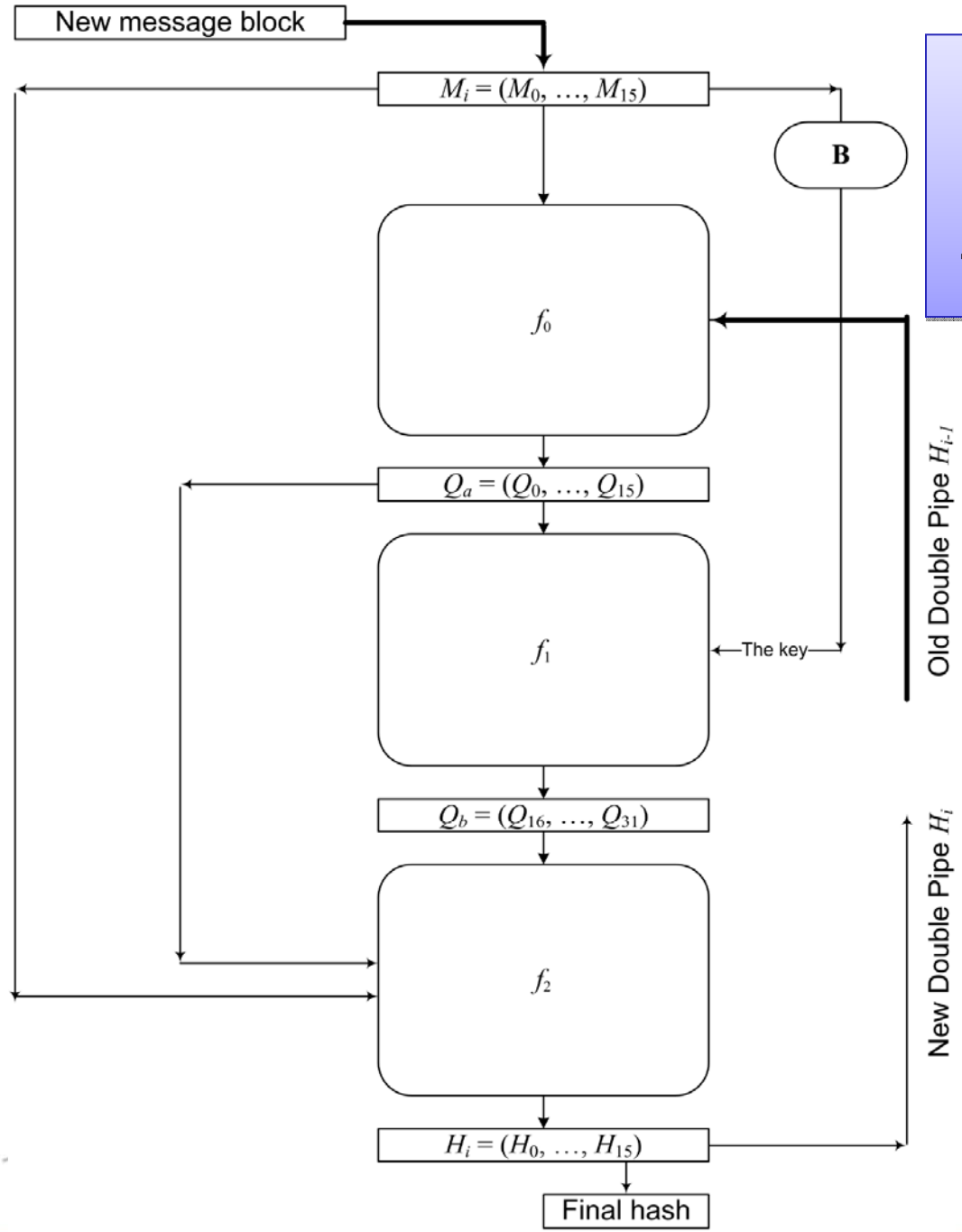
$$H_i = E(M_i, M_i \oplus H_{i-1}) \oplus M_i \oplus H_{i-1}$$

BLUE MIDNIGHT WISH can be seen as generalized PGV6:

$$H_i = f_2(M_i, H_{i-1}, E(M_i, M_i \oplus H_{i-1}))$$

Note: Here the block cipher $E(\,)$ is weak block cipher.

compression function for BLUE MIDNIGHT WISH



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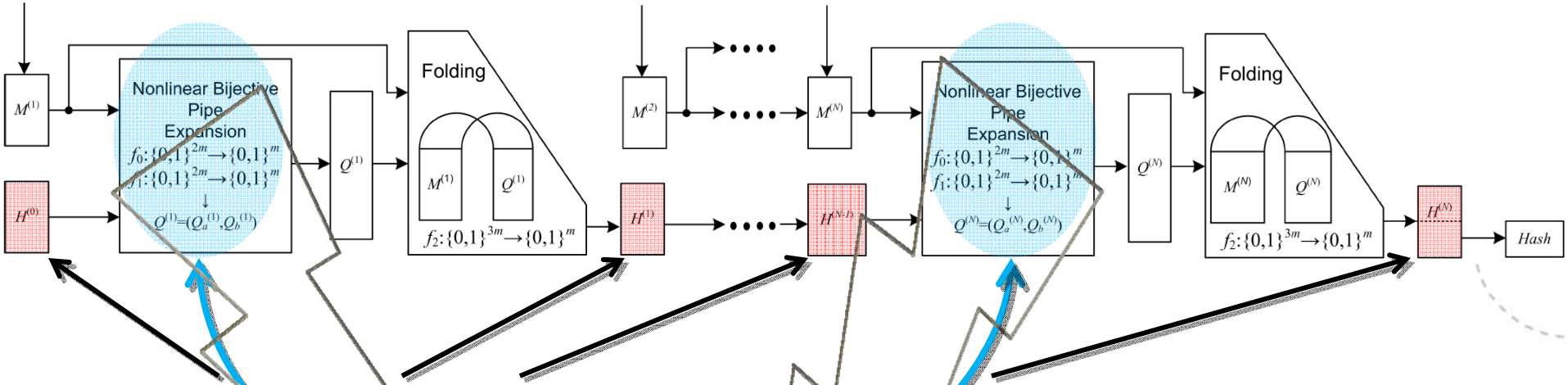
Specific design characteristics for BLUE MIDNIGHT WISH (cont.)



1. Double size chaining (pipe) values
   - For n=224, 256, chaining value has 512 bits
   - For n=384, 512, chaining value has 1024 bits
2. Many entangled bijections
3. Very fast diffusion of initial differentials

Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

1. **Double size chaining (pipe) values $H^{(i)}$**
   - **For n=224, 256, chaining value has 512 bits**
   - **For n=384, 512, chaining value has 1024 bits**

   - **Gives resistance against length-extension attack**
   - **Gives resistance against multi-collision attack**

Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

2. Many entangled bijections

Theorem 2 *(in the documentation)*

1. *When* $H_{i\text{-}1}$ *is fixed,* $f_0(M_i, H_{i\text{-}1})$ *is a bijection.*
2. *When* M_i *is fixed,* $f_0(M_i, H_{i\text{-}1})$ *is a bijection.*
3. *When* Q_a *is fixed,* $f_1(M_i, Q_a)$ *is a bijection.*
4. *When* M_i *is fixed,* $f_1(M_i, Q_a)$ *is a bijection.*
5. *When* Q_b *and* M_i *are fixed,* $f_2(M_i, Q_a, Q_b)$ *is a bijection.*
6. *When* Q_b *and* Q_a *are fixed,* $f_2(M_i, Q_a, Q_b)$ *is a bijection.*
7. *When* Q_b *is fixed, for every distinct value of* Q_a *(resp.* M_i*), the equation* $Q_b = f_1(M_i, Q_a)$ *have a unique solution* M_i *(resp.* Q_a*).*

Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

2. Many entangled bijections

• ***The bijective entanglement, combined with the nonlinearity of the expressions in f_2 gives us confidence that it is infeasible to find collisions, preimages or second preimages of*** **BLUE MIDNIGHT WISH .**

• ***It is hard to find a way to change consistently all three inputs (tied together by non-linear bijective mappings) in such a way that these changes in the 3-times wider input of the compression function f_2 will cancel each other or will lead to controllable changes.***

Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

2. Many entangled bijections

They give one unique property for BLUE MIDNIGHT WISH

Theorem 4. BLUE MIDNIGHT WISH could be seen as a generalization of any of the secure schemes PGV1, PGV2, . . ., PGV12.

Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

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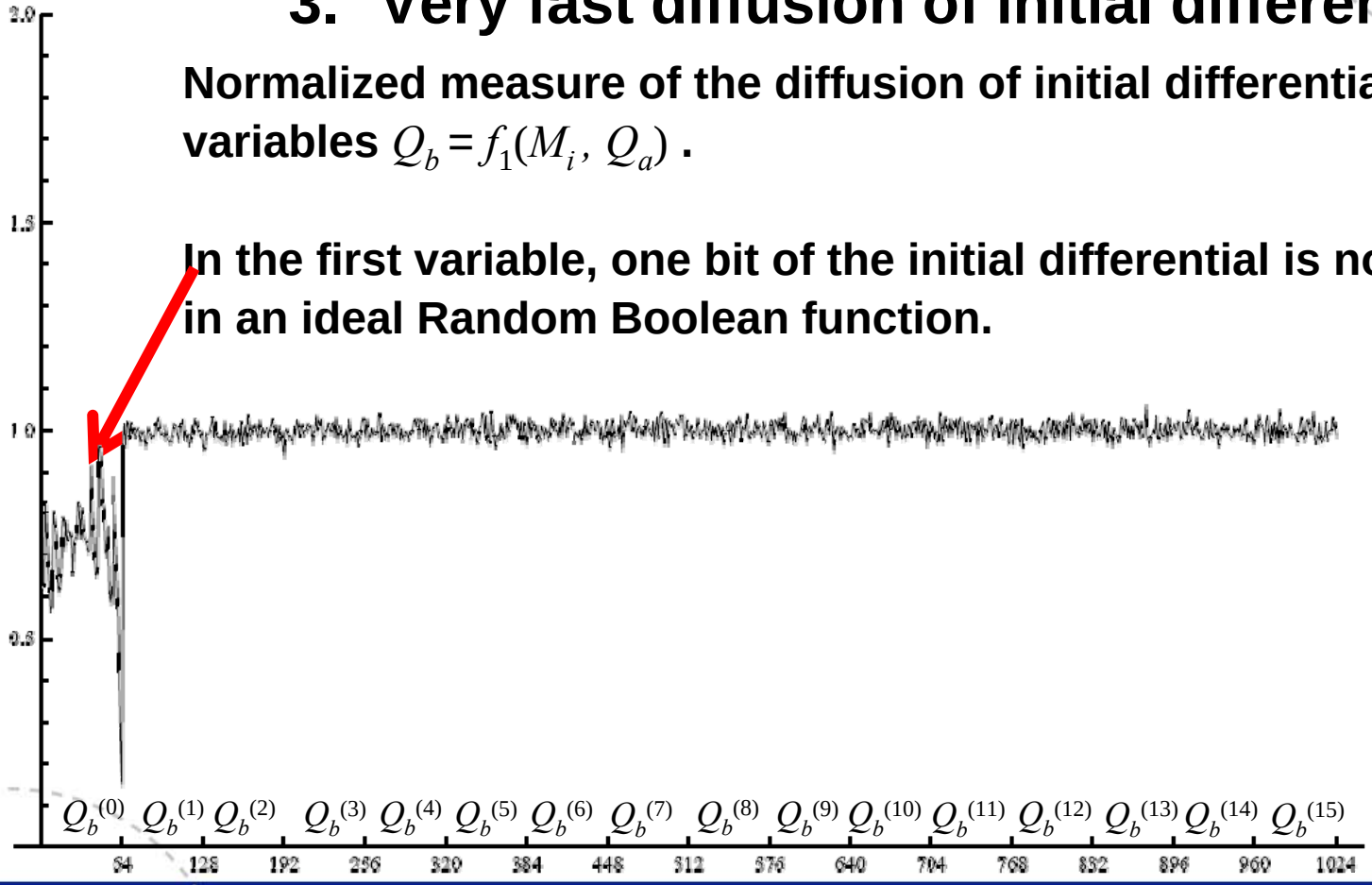
(monomial test)

3. Very fast diffusion of initial differentials

Normalized measure of the diffusion of initial differentials in variables $Q_b = f_1(M_i, Q_a)$.

In the first variable, one bit of the initial differential is not diffused as in an ideal Random Boolean function.



Specific design characteristics for BLUE MIDNIGHT WISH (cont.)

3. **Very fast diffusion of initial differentials**

The fast diffusion combined with entangled bijections – makes BLUE MIDNIGHT WISH resistant against differential cryptanalysis.

SW/HW performance and memory requirements

Software performances of the optimized C implementation on the NIST reference platform

Microsoft Visual Studio 2005, in 32-bit mode
BMW224/256 achieves 7.33 cycles/byte

Intel C++ v11.0.66, in 64-bit mode
BMW384/512 achieves 3.68 cycles/byte

HW – gate count

BMW224/256, ~15,000 gates

BMW384/512, ~30,000 gates

Memory requirements

BMW224/256 needs 264 bytes

BMW384/512 needs 528 bytes

8-bit MCU (ATmega16, ATmega64)

BMW224/256, compiled C code produces ~10KB of machine instructions, speed 1369 cycles/bytes

BMW384/512, compiled C code produces ~55KB of machine instructions, speed 2793 cycles/bytes

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Thank you for your attention!

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